THE WILEY FARM SERIES

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FARM MACHINERY

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FARM MACHINERY

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PREFACE

In the preparation of this volume careful thought has been given to the needs of pupils preparing for specific farming occupations. The problem attitude has been maintained throughout. The "shop jobs" are organized so as to stimulate interest in the actual study of machinery problems and to give specific directions for conducting the work in an orderly manner. By these devices and by the inclusion in each chapter of content regarding machinery types, parts, and adjustments it is hoped that vocational pupils will be assisted in acquiring the abilities necessary to maintain and repair machinery on the home farm or on the farm where they are employed.

The author wishes to express his appreciation of the interest and enthusiastic aid of Dr. O. S. Morgan, Professer of Agriculture, Columbia University, New York City. Credit is also due to the author's wife, Rowena Stone, for all the pen-and-ink sketches; to H. B. Knapp, Director, and the following instructors at the New York State Institute of Agriculture, for their kindly interest: Leon M. Stephens, K. H. Musa, C. A. Peters, G. L. Franke, D. R. MacDougal, and I. L. Williams.

Many helpful suggestions have been received from R. C. S. Sutliff, James Hatch, and K. S. Hart, Supervisors of the New York State Education Department, and their assistance is gratefully acknowledged.

Manufacturers of farm implements, tractors, and accessories have cooperated readily. Credit is due the following companies not only for furnishing photographs for various illustrations, but also for the personal contributions made by their representatives:

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A. A. S.

Farmingdale, New York
June, 1942

FOREWORD

In presenting the third edition of Farm Machinery the author wishes to stress the need for adequate instruction in this subject in all our agricultural training agencies. Never before has this need been so urgent. Under present conditions the repair and reconditioning of farm implements are essential. Agricultural economists in our colleges emphasize the desirability of such work; machinery repair schools conducted by extension departments are crowded; implement dealers report large sales of repair parts; farmers demand more service from each machine to spread their costs over a longer period.

This edition of Farm Machinery has been revised and corrected, and new material has been added, but the same practical methods of study have been retained—methods designed to meet the needs of men who have definite tasks to perform.

Machinery is the means by which accepted methods of husbandry are applied to the farming enterprise. From the first preparation of the soil to the final transportation of products to market, few, indeed, are the steps not accomplished by machinery. At any point, final results may be impaired if the machines fail. Losses from uneven, inaccurate planting, from poor cultivation, or from delayed harvesting of the ripened crops can never be regained. Too often, the machines depended upon to perform these vital processes are not efficient, not in good mechanical condition, or not properly adjusted, owing to neglect or to the lack of adequate information.

Despite its essential nature the study of farm machinery is not often given a suitable share of the student's time. Yet, when studied and operated, machinery readily enlists his lively interest. Ample equipment for repair work can be easily obtained. Repair work can be conveniently fitted into farm shop courses where it cannot be taught as a separate unit of instruction.

In this text a few typical machines have been selected from

the large number available. These few are treated in considerable mechanical detail, with emphasis on their operation, adjustment, and repair. The same treatment may easily be applied to other implements.

A course in farm machinery should give the student definite mechanical skills and information of immediate value. More than this, it can be made thought-inspiring as well. To master the principles of even one machine is to see how the ideas and dreams of men have been forged in steel to become the servants of all mankind.

CONTENTS

CHAPTER I

PLOWS

The plow is one of the most important farm machines. It is an indispensable tillage implement. Plowing is an essential process in the preparation of the seed bed. More thought and engineering talent have been employed in the design and development of the plow than for any other farm implement. Good plowing is an art, requiring knowledge, skill, and experience.

The chief use of the plow is in preparing the seed bed. It inverts the upper layer of soil and turns under and covers surface growth, thus adding humus to the soil. Plowing pulverizes, aerates and loosens the soil, making it more friable and mellow.

In regions where soil blowing is serious, the plow has been partly replaced by the one-way disk (Fig. 2), the field cultivator (Fig. 144), the lister, or the spring-tooth harrow. Any one of these implements will leave the field surface comparatively rough and ridged, with surface trash only partly covered, conditions which lessen soil blowing.

There are three distinct types of plows in common use: disk plows, moldboard plows, and subsoil plows, subsoil plows being a special type used for loosening the subsoil.

The moldboard type is more widely used, and in general gives better satisfaction than the disk. In some soils, however, moldboard plows will not "scour." The soil will stick to the moldboard and thus make good plowing impossible. Under such conditions the disk plow is used to good advantage because the revolving disks are equipped with scrapers which keep them free from sticky soil.

Disk Plows

Disk plows are also used successfully in dry, hard ground and in land-clearing operations where roots, stones, and rocks may be present. Disks of large diameter permit deep plowing (12 to 14 inches). Disk plows do not pack the furrow bottom and build up a plow sole or crust at the bottom of the seed bed.

The disks are set at an angle with the vertical (sloped toward the rear). This angle is adjustable to suit various soil conditions. Penetration is improved by adjusting the angle toward the vertical position.

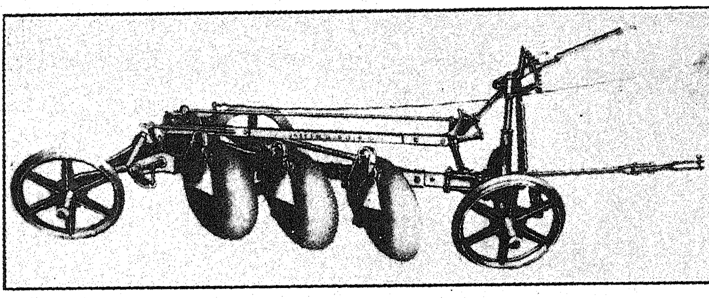


Fig. 1. Tractor disk plow.

Diameter of the disks varies from 20 inches for horse-drawn plows to 28 inches on large tractor plows. Disks are concave, the concavity varying from 3 to 5 inches.

The width of cut of a single disk may be varied by increasing the angle between the disk and the line of travel (lateral or horizontal angle). In multiple-disk tractor plows this angle is usually fixed, but the width of cut per disk may be varied (7 to 10 inches) by spacing the disks further apart on a diagonal beam.

Single-disk (sulky) plows and two- or three-disk gang plows are available for operation with horses. Tractor disk plows with two disks are used with the smaller tractors and as many as seven disks for larger tractors.

Disk scrapers have an important part in the plowing action. To a large extent they determine the amount of pulverizing and the thoroughness with which surface growth and trash are covered. Various types of scrapers are available, all of which require accurate and careful adjustment if good work is to be done.

The disks penetrate primarily because of the weight imposed upon them, rather than because of the downward suction, as is the case with moldboard plows. Disk plows are much heavier per foot of cut than moldboard plows. It is often necessary under difficult conditions to add weight to get good penetration. In spite of their greater weight, disk plows are not materially heavier in draft than moldboard plows of like width; under some conditions their draft is lighter.

As the disk works at an angle with the line of travel, a heavy thrust load, or side pressure, acts upon it, as well as a heavy radial load, or vertical pressure. Disk bearings must be designed to carry these combined pressures, and should be well enclosed to exclude dirt and grit and retain the lubricant. Anti-friction bearings of the ball or roller type, or a combination of both types are employed. They are usually adjustable for wear or have replaceable wearing surfaces. Felt dust seals, oil seals, gaskets, and washers are provided to make a dustproof and oiltight bearing.

The *disk tiller*, a development from the disk plow, is also called a *wheatland disk*, a *one-way disk*, and a *harrow plow*. The last term describes its work well. It penetrates more deeply and covers surface growth better than a disk harrow, and yet does not prepare as deep or as well-pulverized a seed bed as the standard disk plow. Thus a wider strip of land may be worked with the power available, which means rapid preparation of a comparatively shallow seed bed (approximately 3 to 6 inches deep).

Stubble, surface growth, and stalks are cut and mixed with the soil, but not thrown to the bottom of the furrow and covered as completely as with other plows. This condition is de-

sirable in some sections to lessen the washing and blowing of soil. It is well adapted for use as a field cultivator and for weed control on fallow ground.

The disks are assembled in a single gang, all revolving together and throwing soil in the same direction. This implement

FIG. 2. One-way disk or disk tiller.

was first developed for use in the large western wheat fields. For such work the larger sizes are used, cutting 10 feet in width, with as many as sixteen disks, 20 to 26 inches in diameter.

Recently, smaller sizes have been developed for use with light farm tractors. The five-disk size, shown in Fig. 2, cuts

3 feet in width. Space between disks varies according to the diameter of the disks, but is usually 8 to 10 inches.

Subsoil Plows

Subsoil plows are made in a variety of types and sizes. Subsoil knives may also be secured as attachments for moldboard plows.

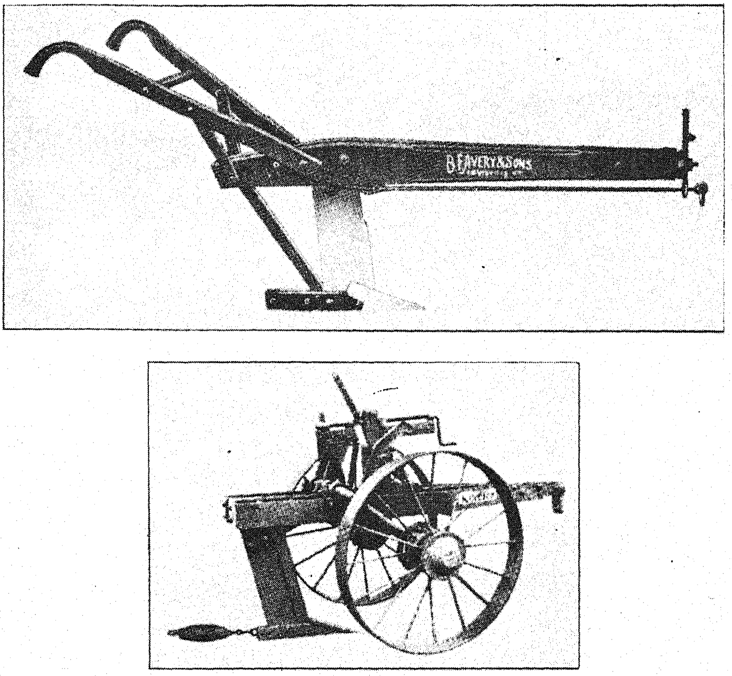


Fig. 3. (*Above*) Horse-drawn subsoil plow. (*Below*) Tractor subsoil plow with mole drain.

All are designed to loosen the subsoil by cutting gashes through it, breaking up hardpan and plow sole, thus permitting the entrance of air and water to the subsoil. Under certain conditions thorough loosening of the subsoil may increase the water-holding capacity of the soil and lessen the water runoff.

The action of the subsoil knives does not bring subsoil to the surface and has no turning or inverting effect on the top soil.

Where the fields are plowed several times a year, as on truck and vegetable farms, and where heavy trucks are used in the fields, soil packing and formation of hardpan may be lessened by the frequent use of subsoil plows, tillers, or chisels, such as shown in Fig. 3. Their use is considered beneficial to the formation of a good root system, especially for crops such as beets or potatoes.

Mole-drain attachments are available for use with tractor-drawn subsoil plows. The *mole* is a heavy steel ball or conical-shaped point which is secured at the lower end of the subsoil standard. When drawn through the ground at the desired depth, it packs the soil to form an underground tunnel, open at the top because of the action of the subsoil knife. The tunnels are laid out to run to suitable outlets and thus permit the escape of the drainage water.

Subsoil plows are not to be considered a substitute for moldboard or disk plows.

Moldboard Plows

Under average conditions moldboard plows pulverize the soil better, leave fewer clods, and cover surface growth more completely than disk plows.

The *walking plow* is used for small fields where a larger plow cannot be employed to advantage. The size of the walking plow is measured by the width of the furrow that it cuts. The most common sizes are 12, 14, and 16 inches.

Riding plows carry the weight of the plow on the wheels and make it possible for the operator to ride. The single-moldboard riding plow called a *sulky* plow, is usually equipped to cut a 14- or 16-inch furrow. Riding plows with two or more moldboards are referred to as *gang* plows. Gang plows are commonly furnished with 12- or 14-inch bottoms.

Tractor plows may be carried on wheels and trailed behind the tractor or may be mounted directly on the tractor. The

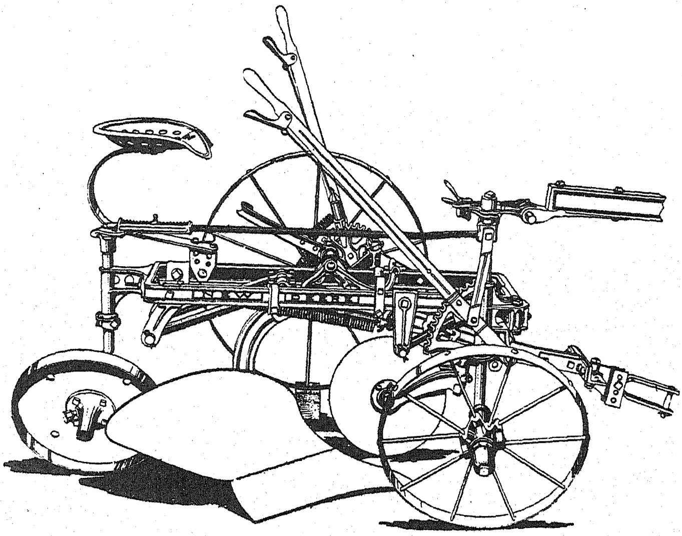


FIG. 4. Sulky plow.

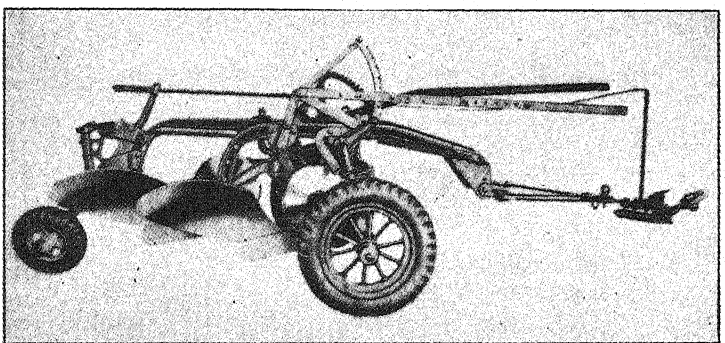


FIG. 5. Trailed tractor plow.

mounted or "integral" type of plow is commonly used on the smaller sizes of tractors. Heavy plows with three or more bot-

toms cannot be easily mounted and are furnished in the trailed or pull type only. Trailed- or pull-type plows are also available in small sizes (one or two bottoms) for use with small tractors.

Fig. 6. Mounted tractor plow.

The direct mounting of implements, such as plows, cultivators, planters, mowers, weeders, sprayers, and dusters, gives maneuverability and control, lessens the difficulty of backing into fence corners and beneath storage sheds, makes possible shorter turns, and eliminates the need for wide headlands.

But these advantages are offset somewhat by the extra work of mounting and dismounting. Trailed machines are more easily attached and detached.

Tractor plows, designed especially for plowing brush land and newly cleared ground, may have a bottom as wide as 20 or 24 inches. For most farm work a 14-inch bottom is the standard size, although 12-, 16-, and 18-inch bottoms are also used.

Types of Plow Bottoms

1. Breaker Bottom or Prairie Breaker. The prairie breaker bottom is low. It has a long, easy slant and turns the furrow over gradually, thus pulverizing the soil very little. This type is used for plowing virgin soil or fields that have a heavy sod. An extension is often bolted to the rear of the moldboard to aid in turning over the furrow slice.

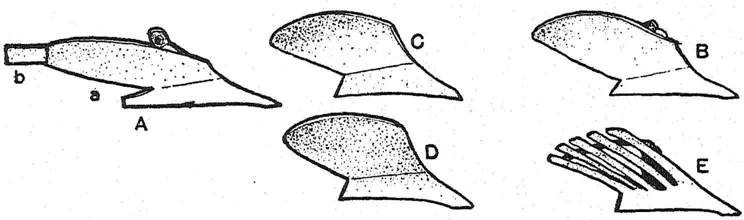


FIG. 7. Types of plow bottoms. *A*—Breaker. *B*—General-purpose. *C*—Stubble or old-land. *D*—Black-land. *E*—Slat-moldboard.

2. General-purpose Bottom. The general-purpose bottom is higher and turns the furrow more abruptly. Hence it pulverizes the soil more than the breaker bottom. It is used on fields of light sod or on ground that has been in crop the previous year. It is not suited for work on virgin soil.

3. Stubble or Old-land Bottom. The stubble or old-land bottom turns the furrow quite abruptly and pulverizes more completely than either the general-purpose or the breaker bottom. It is used on old ground that has been in crops for many years. It leaves the soil mellow and finely pulverized. The stubble bottom cannot be used successfully on new ground or on grass land.

4. Special Plow Bottoms. The black-land bottom has an abrupt angle. The pressure of the soil against it is very heavy. It is used for plowing in black, sticky soils. The shape and angle of the moldboard is such that the soil does not stick to it, but slips off, or "scours," easily.

The slat moldboard has about the same shape as the black-land bottom. There is less metal surface in the moldboard for the soil to stick to; hence this type is used where ordinary moldboards will not scour.

Plow-bottom Materials

1. *Chilled Cast Iron.* Plow bottoms made of chilled cast iron are used in sandy or sandy-loam soils. They are not adapted for clay soils or heavy, sticky soils. Such soils will stick to them and make a good job of plowing impossible. When the molten iron is poured, one face of the mold is lined with metal. As the molten iron strikes this metal, it cools very quickly. This causes the crystals of metal to turn on edge. These crystals are very hard and resist well the wearing effect of the soil.

The parts of the chilled cast-iron bottom are comparatively cheap. When the shares have worn out of shape, however, they cannot be reshaped but must be thrown away because cast iron cannot be forged. In consideration of their cheapness, this is not a serious objection to their use, and they are widely used where the soil conditions are suitable.

2. *Soft-center Steel.* This is made of three layers welded together. The two outside layers are of hard steel. The inner layer is of softer steel which acts as a cushion for the outer layers. The hard steel comes into contact with the soil. It is very smooth and takes a high polish. Clay soils and heavy soils do not stick to it but are readily shed. Hence this material is used where the soil is heavy or where cast-iron plow bottoms will not scour. The soft inner layer helps to prevent breakage.

Soft-center-steel plow bottoms are more expensive than those of chilled cast iron. Soft-center-steel shares, however, may be

reshaped by forging when they are worn. The process of sharpening steel shares will be discussed later.

These shares are likely to break in rocky land, but do not break as easily as chilled-iron shares. They wear faster in sandy soils than chilled iron, but for plowing on heavy or sticky soils they give much better results. Soft-center-steel plow bottoms are lighter in weight than chilled-iron bottoms.

3. *Step-off, Soft-center Steel* (Used in Moldboards). In this construction the soft center is stepped off, as shown in Fig. 8*C*, so that a wider layer of hard steel is present in the moldboard where the wearing effect of the soil is greatest.

4. *Off-center, Soft-center Steel.* In this type the three layers of steel are not of equal thickness. The hard outer layer which makes contact with the soil is made thicker in order that it may withstand the severe wearing action on the soil in its passing across the surface.

5. *Crucible Steel.* This solid, low carbon steel is much softer and more malleable than soft-center steel. It does not break easily, and crucible-steel shares are good for stony land and may be used with soft-center steel or chilled cast-iron moldboards.

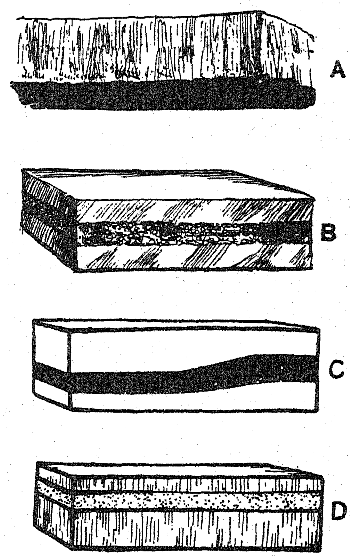


FIG. 8. Plow-bottom materials. *A*—Chilled cast iron. *B*—Soft-center steel. *C*—Step-off, soft-center steel. *D*—Off-center, soft-center steel.

Crucible-steel moldboards are not satisfactory for use where scouring conditions are difficult.

Crucible-steel shares are cheaper than those of soft-center steel. They may be sharpened easily with a file, or hammered without heat.

Construction of Plow Bottoms

Frog. The frog is the heart of the plow bottom, all the other parts being attached to it. The frog may be made of cast iron or steel. The cast-iron frog is larger and thicker than the steel frog. An easy method of distinguishing between cast-iron and steel parts is to observe the manner in which they are numbered. If the number has been stamped into the metal, the part so numbered is steel. If the number is raised, showing that the figures or letters were molded with the part, the material has been cast, not forged to shape.

Share. The share cuts the furrow loose and elevates it to the moldboard. Shares are made of the materials described above. They are carefully shaped, as the correct shape is essential to good plowing. An old share fails to do good work not only because it is dull but also because it has lost its original shape. The share is either bolted to the frog or, by means of a steel lug and eye bolt, attached to it. Shares attached in this manner, or with a similar device, are called *quick, detachable shares.* These are now more commonly used than bolted shares.

Moldboard. The moldboard lifts and turns the furrow that is cut loose by the share. The angle that the moldboard makes with the landside determines the amount of pulverization that will take place. This angle is small on the breaker plow, with the result that the furrow is turned gradually and the soil is pulverized very little. The angle between the moldboard and the landside of a stubble-bottom plow is quite abrupt. Such a moldboard turns the furrow quickly and pulverizes it well. The angle of a general-purpose plow bottom is less than that of the stubble bottom but more than that of the breaker bottom.

Special plow bolts are used to attach the moldboard and the other parts of the plow bottom to the frog. These are countersunk so that the head of the bolt will be flush with the surface. Roundhead bolts, with a small tit to prevent turning, or squarehead bolts are used.

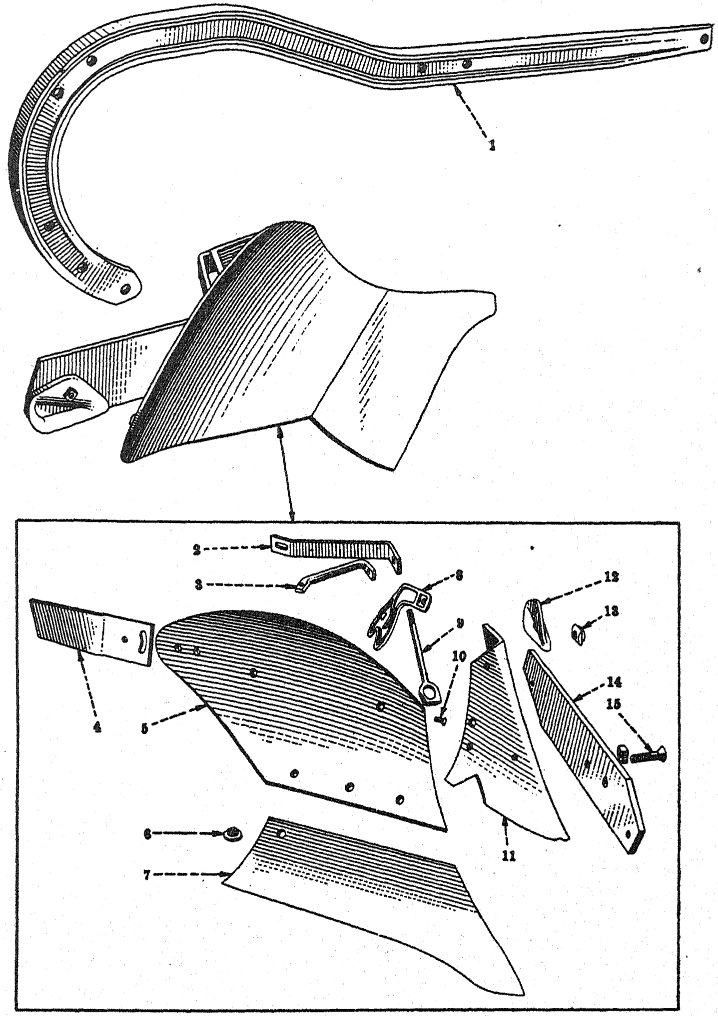


FIG. 9. Beam and bottom. 1—Beam. 2—Moldboard brace. 3—Bottom brace. 4—Mold extension. 5—Mold. 6—Flange washer. 7—Share. 8—Lock bolt bracket. 9—Lock bolt. 10—Lock-bolt stud. 11—Frog. 12—Heel casting. 13—Beam washer. 14—Landside. 15—Special heat-treated plow bolt.

Moldboards are made of chilled iron, soft-center steel, or crucible steel. The surface of the moldboard must be very smooth and capable of taking a high polish. Good plowing requires that the soil pass off easily from the moldboard, without sticking. The shedding of the soil from the moldboard is called *scouring*. The manufacture and design of plow moldboards that will scour well under adverse soil conditions are subjects of continuous experiment for the plowmaker, and the problem of skillful and intelligent management of the plow under such conditions should receive the best effort of the plow operator.

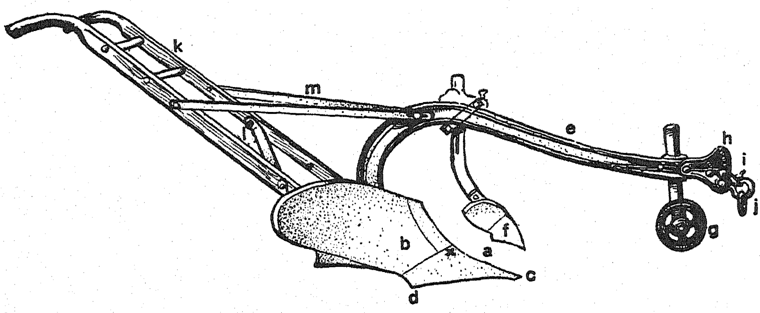


FIG. 10. Parts of the walking plow.

Figure 10 shows a moldboard with a removable cutting edge. This is called the *shin* of the moldboard. As most of the wear comes at this point, there is an advantage in having a removable shin. Some cast-iron shares include the shin as a part of the share, thus providing for the easy replacement of these two wearing parts. Other shares are made with a renewable slip point.

The extra joint, however, between the shin and the moldboard sometimes interferes with scouring when soil conditions are difficult.

Landside. The landside presses against the wall of the open furrow, keeping the plow straight by resisting the side

pressure on the moldboard, which is caused by inverting the furrow.

Beam. Plows are pulled from the beam, which is bolted to the frog. The beam is curved upward where it passes over the plow bottom to give throat room or clearance for trash at this point.

Either wood or high-carbon steel is used for walking-plow beams. The wood beam is larger than the steel beam, but lighter. The steel beam is used on tractor plows.

Jointer (Fig. 10*f*). The jointer is commonly used with the walking plow. It is fastened to the plow beam with an adjustable clamp. The adjustment of the jointer is very important and will be thoroughly explained later. The jointer is a miniature plow. It cuts and turns a small furrow at the inner edge of the main furrow. This causes better covering of surface growth when the main furrow is turned over. Jointers are particularly useful in plowing sod fields or in turning under growing crops to enrich the soil.

Gauge Wheel (Fig. 10*g*). The gauge wheel is connected to the beam, the clamp that holds it, providing for vertical adjustment. The gauge wheel keeps the plowing uniform in depth and causes the plow to run steady.

Clevises (Fig. 10*h, i, j*). The clevis is a device for connecting the plow to the power that draws it. Walking-plow clevises are made to provide both vertical and horizontal adjustment. The vertical clevis (*h*), bolted to the end of the beam, makes it possible to raise or lower the point of hitch. The holes in the horizontal or cross clevis (*i*) provide for moving the point of hitch toward or away from the "land" (unplowed ground). The small clevis (*j*), called the *evener* clevis, connects the eveners with the cross clevis. The clevises are connected with each other by bolts or pins.

Eveners. Two-horse eveners are used for walking plows. Figure 16 shows the evener bar, *c* and *d* the single trees, *e* the

single-tree hooks. The traces of the horse's harness are hooked to the single-tree hooks. The single trees are attached to the evener bar by means of metal straps (*f*). The various evener parts to which these letters refer are shown in Fig. 16 as part of a five-horse hitch. All the parts mentioned here, however, are used, as stated, with the walking plow.

Plow Handles (Fig. 10*k*). Plow handles are usually made of wood, a good grade of oak being used for this purpose. Heavy steel bars connect the lower ends of the handles to the plow bottom.

Set of the Plow Bottom

1. Vertical Suction (Fig. 11). If a new plow bottom is placed on a level floor, it will touch the floor in three places: the point of the share (*a*), the wing of the share (*b*), and the heel of the landside (*d*). There should be a vertical clearance of 3/16 to 1/4 inch at the point indicated by the arrow (*c*). There should also be a vertical clearance of 1/8 to 3/16 inch at the point indicated by the arrow (*e*). This clearance is caused by the fact that the point of the share is lower than the bottom line of landside and also lower than that part of the cutting edge of the share indicated by the arrow at *e*. When the share is made, the point is bent down. This causes the point of the share to enter the ground first. The plow penetrates easily and stays in the ground because of the downward inclination of the point. The action of the point in entering the ground and

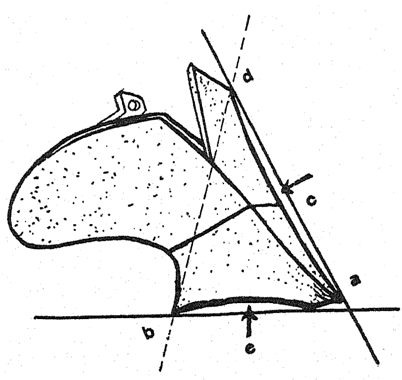


Fig. 11.—Set of the walking-plow bottom.

holding the plow bottom down so that it cuts the proper depth of furrow is referred to as *vertical suction.* The point of a worn share is shown in Fig. 13. The underside of the point has been worn away. Such a share would give no vertical suction, and the plow would not penetrate properly.

2. **Horizontal Suction** (Fig. 12). If a new walking-plow bottom is turned on its side on a level floor, it will be noted

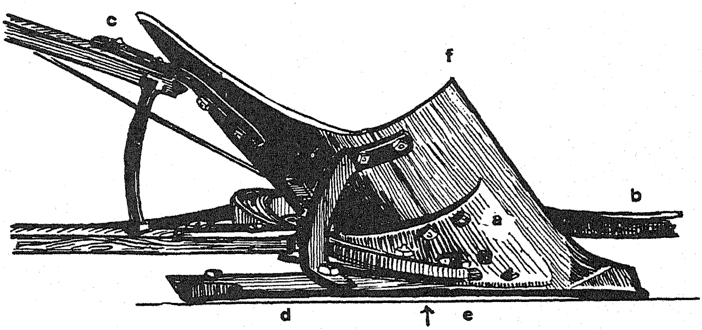


Fig. 12. Inverted view of walking-plow bottom.

that the heel of the landside and the point of the share touch the floor. There will be a clearance of $\frac{1}{8}$ to $\frac{1}{4}$ inch at the point indicated by the arrow at *e*, because the point of the share is turned slightly to the side, or outside the line of the landside.

When the plow is in operation, the share point tends to suck sidewards, or toward the "land," because the share point is bent toward the side. This is referred to as *horizontal suction,* or *land suction.* A plow bottom with good land suction cuts a uniform width of furrow. It maintains the same width of furrow in all parts of the field. Figure 13 shows a share worn so much that the plow would have no land suction. Plowing with such a share would be very difficult: the plow would not hold the land, the furrows would not be even in width, and the operator would have to force the plow to cut more

land by manipulating the plow handles. The pressure of the furrow's being turned over by the moldboard has a tendency to pivot the plow bottom, turning the share point toward the plowing (away from the land). This tendency is overcome

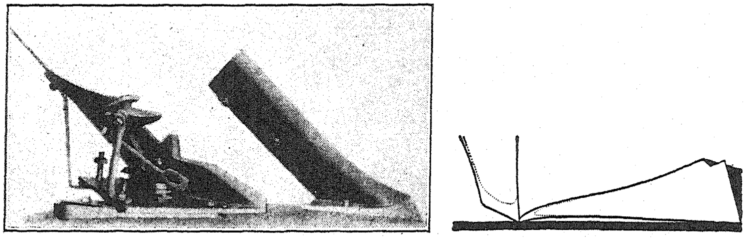


Fig. 13. Quick, detachable shares and worn share points (dotted lines show how share points wear).

partly by the landside but also to a large extent by the land suction of the share point.

3. **Wing Bearing** (Fig. 12*f*). The wing of the share is one of the three points to touch the level floor. The share at this point, on walking plows, is made level for about 1 inch in order to provide a bearing for the outer corner of the plow bottom. This portion of the bottom of the share (indicated at *f*) is called the *wing bearing.*

The wing bearing serves as a runner to support the walking-plow bottom and keep it running steadily. Riding-plow and tractor-plow shares do not require a wing bearing since the plow bottom is supported by the wheels.

JOB 1

TO REPAIR A WALKING PLOW

Procedure

1. Place the plow on a level floor and examine the set of the plow bottom to determine:

(*a*) The amount of vertical suction.
(*b*) The amount of land suction.
(*c*) The amount of wing bearing.

2. Sharpen and reshape the share or replace it with a new one if necessary. (See Job 2.)

3. Examine the landside and the landside sole for wear. If these parts are badly worn they should be replaced. Landsides wear most at the underside toward the rear, becoming shorter and thinner than when new.

4. Examine the moldboard. Remove all rust spots with emery paper. Moldboards last longer than shares or landsides, but sometimes become so worn or scratched that they must be replaced. The end of the moldboard is sometimes worn off by dragging the plow to and from the field, allowing it to ride on the end of the moldboard. To prevent this, a drag made of planks should be provided.

5. Examine all the bolts that hold the landside, share, and moldboard to the frog. Tighten these bolts and see that the bolt heads do not project from the surface of these parts. The joint between the share and moldboard must be smooth and even. If the moldboard were higher than the edge of the share, the soil would stick to it and the plow would not scour properly. Shims of cardboard placed between the share and the frog will bring the share up into line properly; or, if the moldboard is too low, the shims may be placed between it and the frog.

6. Examine the beam (if a steel beam is used) to see if it has been bent out of shape. Sprung beams cause bad plowing. The plow will not do its work properly. The ordinary adjustments will not remedy the troubles caused by a sprung beam. A beam may become sprung laterally (in or out) or vertically (up or down), or it may be sprung both vertically and laterally. If the beam is sprung, the carefully designed plow-bottom parts can no longer meet the soil at the correct angle and the whole unit becomes inefficient.

The vertical distance from the underside of the beam to the floor should be between 14 and 16 inches (when measured with a new share on the plow).

The horizontal distance from the landside edge of the share point to a point directly below the landside edge of the beam should be from ½ to ¾ inch for a two-horse plow. For a three-horse plow these two points should be practically in the same vertical line.

To straighten a bent steel beam, proceed as follows:

(*a*) Determine the exact point where the beam is bent.

(*b*) Remove the beam from the plow and take off all parts attached to it.

(*c*) Heat the beam in the forge, at the place where it is bent, to a dull cherry red.

(*d*) Hammer the beam on the anvil so as to bring the bent portion back into place. The chief difficulty is in keeping the steel at the proper heat. Too much heat will change the temper and weaken the beam.

(*e*) If another plow beam of the same type is available, compare the two. Wooden beams will not bend, but may crack or break.

Examine all the bolt holes through the beam (wooden beam). Test to see if the bolts completely fill the holes in the beam. If they do not, the bolts will loosen when the plow is in operation, making it impossible to keep the parts properly adjusted. There are two methods by which this condition may be remedied:

(*a*) By using a larger bolt. To do this, it is usually necessary to enlarge the hole through the metal part also, so that the larger bolt will pass through it. This may be done by drilling or reaming out the hole. If the hole needs to be enlarged only slightly, the work may be done with a round file. This method is the best to use where the metal part is of such a size that a larger hole will not be likely to weaken it.

(*b*) By shaping a hardwood plug to fit the hole. Cover the plug with glue and drive it into the hole. When the glue is set, bore out the hole to its original size.

and use the same-sized bolt. This method is best where the metal piece is likely to be seriously weakened if the hole through it is enlarged.

These two methods will be found useful in repairing many kinds of farm machines.

7. Sharpen the jointer. This may be done by grinding it on the grindstone or emery wheel to restore its original wedge shape. (See Fig. 36.) If badly worn, jointer points should be replaced.

8. Inspect the bearing of the gauge wheel. This is usually made so that it can be easily replaced when worn.

9. Tighten the bolts that hold the vertical clevis to the beam. Examine the clevis bolts and replace them if they are worn.

10. Examine the eveners. Walking-plow eveners are usually made of wood. The single-tree hooks sometimes get loose, and the bolts or pins through the single-tree straps and evener straps should be made to fit properly the hole through the wood. (See Operation 6 of this job.)

11. Tighten the bolts that attach the handles to the plow bottom. Examine the handle braces. Replace broken or split handles.

12. Paint all the metal and wooden parts of the plow except the wearing surfaces of the share, moldboard, and landside. These surfaces should be covered with a thick coating of heavy grease. This prevents the rusting of these highly polished parts, and the grease can be easily wiped off when the plow is to be used again. Rust is the great enemy of farm machinery. Plow bottoms, in particular, are quickly damaged by rust. A small rust spot on the share or moldboard of the plow may cause a great deal of trouble and make good plowing impossible.

All farm machines should be painted before they are stored away after the season's work. Paint costs little and yet greatly lengthens the life of machinery. A good repair job is not complete without painting.

JOB 2

TO SHARPEN PLOW SHARES

Procedure

Determine whether the share is made of chilled cast iron or of soft-center steel. (See p. 12.) Cast-iron shares cannot be forged.

If the share is made of chilled cast iron, grind the entire cutting edge on the emery wheel or grindstone. It should be ground to an abrupt, beveled edge. A thin edge will not have the strength to resist the severe wear to which plow shares are subjected. Make the edge sharp but with an abrupt, steep angle. Grind on the upper side of the share.

Chilled-iron shares which are worn to the extent shown in Fig. 13 have lost their land and vertical suction. It is useless to sharpen such shares as they cannot be restored to their original shape. Such shares should be replaced with new ones. Chilled-iron shares cannot be heated and forged.

Sharpening Soft-center Steel Shares (Fig. 14)

NOTE. Sharpening steel shares is the most difficult of all plow-repair work. It is discussed here because a knowledge of the proper shape of the share and of the importance of sharp shares is vital. Unless the student has ample opportunity for practice and has had some previous experience in working steel, this problem had better be delayed until the latter part of his course. The various steps given below should, however, be carefully studied; or, better still, the student should be afforded the opportunity of watching a skilled blacksmith reshape and sharpen a soft-center steel share.

1. Obtain a good, clean coke fire in the forge.

2. Draw with chalk on the floor the outline of a new share. This will serve as a guide in reshaping the worn share.

3. Put the share in the fire as shown in Fig. 14, and heat it to a dull cherry red, but no hotter. Heat only a few inches of the cutting edge of the share, or just as much as can be hammered at one time. This is accomplished by keeping green

coals under the share except for the few inches that are to be heated.

4. Hammer the heated portion of the edge, as shown at *B*, with the bottom of the share flat on the anvil. The share is hammered on the upper side, and is thus drawn down to a keen cutting edge.

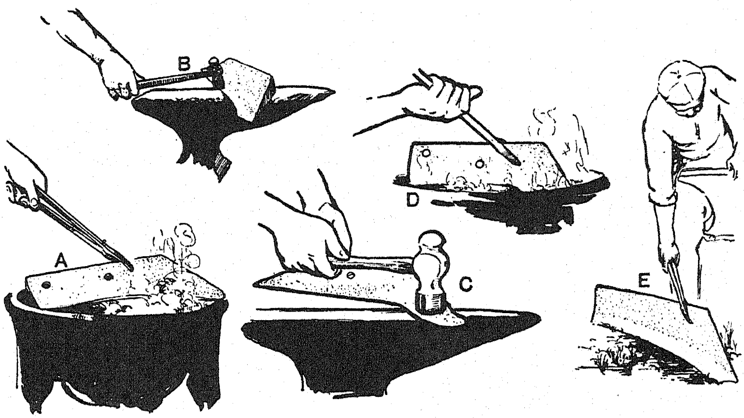


FIG. 14. Sharpening soft-center steel plow shares.

Continue this process until all the cutting edge of the share has been hammered and it coincides as nearly as possible with the chalk outline of a new share.

5. Place the share point in the fire and heat it to a cherry red. Forge it out until it has the proper shape. To determine this, check it with the chalk outline on the floor.

6. Heat the point again and bend it down $\frac{1}{8}$ to $\frac{3}{16}$ inch. To do this, hold the share on the anvil and strike it lightly with the hammer as shown at *C*. This will give a gradual downward slant to the share point. Do not strike the point where it extends beyond the anvil.

7. Temper or harden the share by drawing it slowly through the fire with the cutting edge down (*D*). The entire share should be heated to a uniform cherry red, $\frac{1}{2}$ inch back from

the cutting edge. When the point and entire cutting edge have reached this heat, withdraw the share from the fire and place it in the ground as shown at *E*. Let it remain in this position until thoroughly cooled.

Riding Plows

The riding sulky plow (Fig. 4) and the riding gang plow are probably the most widely used types of riding plows.

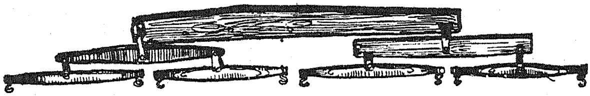


Fig. 15. Gang-plow eveners, "four-horse-abreast hitch."

Three-horse eveners are usually supplied with 16-inch sulky plows. Four-horse eveners (Fig. 15) or five-horse eveners (Fig. 16) are furnished with two-bottom (14-inch) gang plows.

Construction of Riding Plows

Set of the Riding Plow Bottom. The sulky plow has a one-point bearing, not a three-point bearing like the walking plow. If a sulky plow is placed on a floor and properly leveled (to do this it is necessary to place a 6-inch block under the land wheel), when the plow bottom is lowered only the share point touches the floor. The heel of the landside and the wing of the share do not touch (Fig. 17).

Thus, when the plow is in operation, the point of the share is lower or deeper than the heel of the landside. The heel of the landside does not bear heavily against the bottom or the side of the furrow as it does in the walking plow. The wheels of the sulky plow carry the weight of the plow bottom and also relieve the landside of much of the side pressure. When a properly adjusted sulky plow is in operation, there should be but slight pressure between the landside heel and the bottom of the furrow, and also but slight pressure between the landside and the furrow wall (Fig. 18).

The sulky plow share has no wing bearing at the outer edge of the share. This is not required in sulky plows because the wheels support the plow bottom evenly and keep it running steadily.

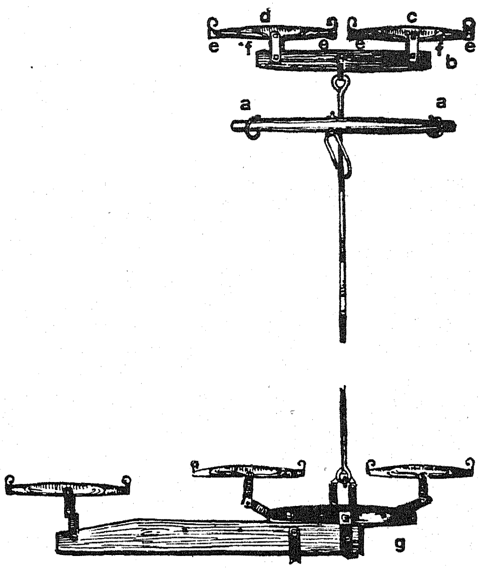


FIG. 16. Gang-plow eveners, "five-horse strung-out hitch."

Frame. The frame is made of flat bars of heavy steel. The wheels and axle are attached to the frame and the plow bottom is hung from it. The frame should be rigid and well braced.

Bails. The bottom of the standard riding plow is attached to the frame by means of the bails which connect the frame and the beam. Sulky plows are made with one or two bails. Each bail has one bearing on the beam and two on the frame. The bails act as cranks to aid in lifting and lowering the plow.

All wheel plows have a decided advantage over walking

plows in that the plow bottom may be easily lifted from the ground at the ends of the field or when they are being transported to or from the field. It is not necessary to drag the plow bottom along the ground as is required with the walking plow.

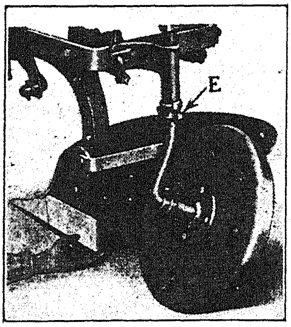


FIG. 17. Method of giving down suction to a wheel plow having an adjustable rear-furrow wheel.

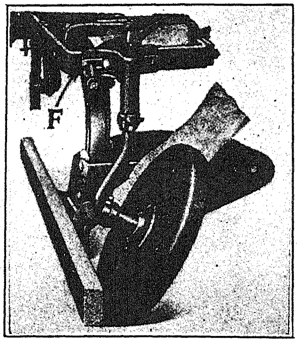


FIG. 18. Method of giving landside suction to a wheel plow having an adjustable rear-furrow wheel.

Lifting Levers. Both a foot lever and a hand lever are usually provided for lifting and lowering the plow. These are connected between the beam and the frame. Two foot pedals are provided for the foot lift, one to lower the plow and the other to raise it. When the plow is lowered, the bails lock against the bail stops. These cause the plow bottom to ride steadily and make the connection between the frame and the plow bottom more rigid. Figure 19 shows the foot-lift lever in the lifted position.

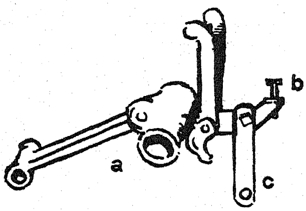


FIG. 19. Foot-lift lever used on sulky and gang plows.

By means of the setscrew (*b*) it is possible to adjust the lifting-lever link (*c*), so that if the plow strikes an obstruction the jar will release the link and the plow will be lifted and

pass over the obstruction. This is desirable in plowing stony ground. A plow set in this manner is said to "float."

Wheels. Sulky plows are usually provided with three wheels.

(*a*) *Land Wheel.* The land wheel is so named because it runs on the unplowed ground or "land." It is the largest of the three wheels and is placed on the same side of the plow as the landside.

(*b*) *Front-furrow Wheel.* The front-furrow wheel is smaller than the land wheel. It is placed in front of the plow bottom and runs in the open furrow.

(*c*) *Rear-furrow Wheel.* This is the smallest of the three wheels. It is placed directly behind the plow bottom and runs in the furrow opened by the plow bottom.

Alignment of Wheels. The land wheel is set perfectly straight or vertical. It should travel forward in a straight line, as indicated in Fig. 20*e*.

The front-furrow wheel is usually set at an angle, as shown at *a*. This setting resists the side pressure exerted against the moldboard by the furrow. The front-furrow wheel also travels slightly toward the land (notice the arrow at *a*). The "lead" of this wheel is controlled by a small lever, called the *landing lever*. This is connected to the axle. This lead toward the land aids in maintaining furrows of even width, particularly on hillsides. The landing lever is helpful when the operator is straightening out a crooked furrow. The rear wheel is also set at an angle and is given a lead away from the land (notice the arrow at *b*). The amount of lead is adjustable. This wheel should run a trifle closer to the furrow wall than the landside. The angle at which it is set, the lead away from the land, and its placement close

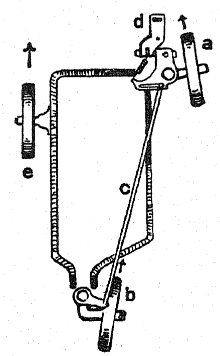


FIG. 20. Alignment of sulky-plow wheels.

to the furrow wall all help to reduce the pressure against the landside.

Axles. The axles provide a bearing for the wheels and connect the wheels to the frame of the plow. The land wheel axle is attached to the frame by means of a bracket. The axle passes through one bearing in the bracket and into another bearing on the frame. The land axle is shaped so that the land wheel will set vertically. Axles are made of high-carbon steel. If an axle becomes bent or sprung, the plow is thrown out of adjustment and will not work properly. A bent axle may be straightened by the method used in Job 1 for straightening a steel beam.

The axle for the rear-furrow wheel is shaped as shown in Fig. 17. This sets the wheel at an angle. The axle passes through a bracket on the rear of the frame. It may be raised or lowered slightly by loosening the setscrew in the collar through which it passes. This adjustment is used to control the vertical suction of the plow bottom. It should be set so that the heel of the landside is about ½ inch above the floor when the plow is level.

Levers. Two hand levers are usually provided on sulky plows.

(*a*) The *land-wheel lever* is attached to the land-wheel axle. It is used to raise or lower the plow. A ratchet with several notches makes various adjustments of this lever possible. The land-wheel lever is sometimes called the *depth lever* as it is used to keep the plow at the proper depth.

(*b*) The *front-furrow-wheel lever* is connected to the front axle and the frame. It is also provided with a lever ratchet. The action of this lever raises or lowers the frame on the front axle. It is sometimes called the *leveling lever.*

Any ordinary change in depth can be made with these two levers. If considerable change in the depth of plowing is required, it may be necessary to change the adjustment on the

axle of the rear-furrow wheel and to change the position of the bail stops.

Steering Device (Fig. 20). Turning or steering the plow is accomplished by the action of the front- and rear-furrow wheels. They are connected by means of a long connecting rod (*c*). The pole is bolted on to the pole plate (*d*). This is connected by a bracket to the axle of the front-furrow wheel. As the horses are swung to the left, these parts take the position indicated for a left turn. When turned to the right, they are in the opposite position.

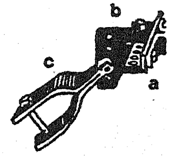


FIG. 21. Clevises used on sulky and gang plows.

Clevises (Fig. 21). A clevis bar (*a*) is used on sulky plows for the horizontal adjustment of the hitch. The clevis bar has a series of holes which provide a wide range of adjustment. It is bolted to the front end of the beam.

A vertical clevis (*b*) is connected to the clevis bar. The various holes in this clevis are used for the vertical adjustment of the hitch.

The evener clevis (*c*) attaches the eveners to the vertical clevis.

Clevises are made of steel or of malleable iron. Steel is the better material because these parts are subjected to severe strain.

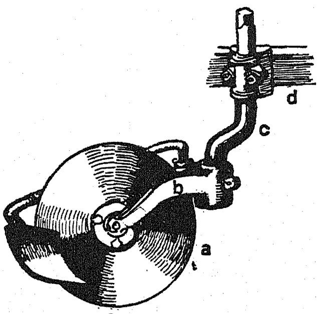


FIG. 22. Combination coulter and jointer.

Coulter (Fig. 22). A rolling coulter is commonly used with the riding plow, although some riding plows are equipped with a jointer like the one described for walking plows. The work performed by the rolling coulter, however, is quite different from the work of the jointer.

The coulter is placed so that its center, or hub, is almost directly above the share point. The sharp edge cuts the side

wall of the furrow. It is usually set to penetrate about half the depth of the furrow, and is placed about ½ inch inside (toward the land) of the landside. Definite instructions for setting the coulter are given later.

The coulter yoke (*b*) is provided with a bearing on which the coulter blade revolves. These bearings should be well lubricated and must be renewed when worn, for a loose bearing causes the coulter to wobble and do poor work.

The coulter shank (*c*) connects the coulter to the plow beam. The lower end of the shank passes through the yoke and is secured by means of a setscrew and a collar. The upper end, which is square, is bolted to the plow beam with a clamp (*d*). A wrench is used on this square end to set the coulter toward or away from the land.

The use of the coulter improves the plowing. If properly adjusted, the coulter leaves the furrow wall clean cut and the furrow bottom clean. It also reduces the draft of the plow since the side wall of the furrow is cut by the sharp, shearing action of the coulter and is not torn loose by the shin of the moldboard.

Combination Coulter and Jointer. The use of the coulter and the jointer in combination, as depicted in Fig. 22, is desirable because the advantages of both machines are obtained.

The jointer works better when used in combination with the coulter than when used alone. The coulter cuts the surface trash into short lengths so that it does not catch and drag on the jointer but is completely inverted and covered. The jointer is connected to the yoke of the coulter. It is adjusted so that the point is directly below the coulter hub and just clear of the coulter blade.

The combined coulter and jointer are regular equipment on tractor plows, under which subject they are more fully described.

Frameless Riding Plows

The riding plows described in the foregoing pages are known as *high-lift* plows, that is, the entire plow bottom may be lifted quite clear of the ground. To obtain this high lift, a complete frame is necessary.

Riding plows are also built without frames and are then called *low-lift* plows. The axles of the land wheel and the front-furrow wheel are carried in bearings bolted to the beam. By means of levers these axles serve to raise or lower the point of the plow. The heel of the plow is not lifted by the levers. Both the front- and rear-furrow wheels are designed so that short, square turning is possible. A turn in either direction may be made without raising the plow from the ground. This type of plow may be operated without a pole. The direction of pull on the clevis controls the steering of the plow.

Hillside Plows

Satisfactory plowing on hillsides and slopes often requires the use of a plow especially designed for such work. Such plows will turn all the furrows in the same direction; all may be thrown to the right, or to the left, as desired. This makes it possible to eliminate all dead furrows (ditches) and back furrows (ridges). When plowing is done on hillsides or on contours to control soil erosion, in strip farming, on small, irregular fields, or on strips between irrigation lines, back furrows and dead furrows are quite objectionable. With ordinary moldboard plows, which are nearly always *right-hand* (because they turn the furrow to the right), back furrows and dead furrows cannot be prevented, except by idle travel.

Figure 23 shows a walking plow designed for hillside work. The moldboard may be reversed or swung from one side to the other. On the first trip across the field, the furrow may be turned toward the operator's right. At the end of the field the plow is reversed, and on the return trip a second furrow is

thrown against the first, but this time the furrow is turned toward the operator's left.

For plowing steep hillsides this type of plow is widely used because all furrows may be thrown downhill. It also makes possible the elimination of all dead furrows in the field. Dead furrows are quite objectionable in hillside fields because they form gullies which may wash away the soil.

When the moldboard is reversed at the end of the furrow, the jointer is automatically moved also, so that it is in the

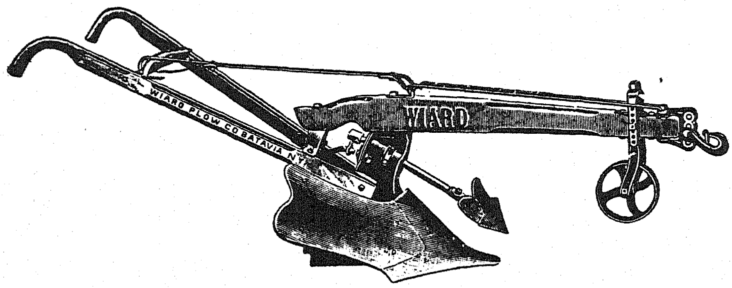


FIG. 23. Hillside or swivel walking plow.

proper position for the next furrow. The clevis also is moved over into the proper line of draft for the new setting. The moldboard is secured in either the right- or left-hand position by a spring-pressure lock.

The two-way sulky plow has the same advantages as the hillside or swivel plow. One of its plow bottoms is right-hand, and the other left-hand. Only one of the plows is in action at one time. When the left-hand plow is in position to turn a furrow, the right-hand plow is raised. On the return trip the left-hand plow is raised and the right-hand plow lowered into the working position. Thus the second furrow is laid against the first. In this way an entire field may be plowed with no dead furrows.

The hitch or clevis at the front of the plow shifts automatically from one plow to the other and thus maintains the proper line of draft.

On steep hillsides it is usually necessary to shift the pole slightly toward the land in order to keep the plow cutting a uniform width of furrow. A special lever, called the landing lever, accomplishes this. It acts to incline the plow slightly uphill and to overcome or offset its tendency to slip downhill.

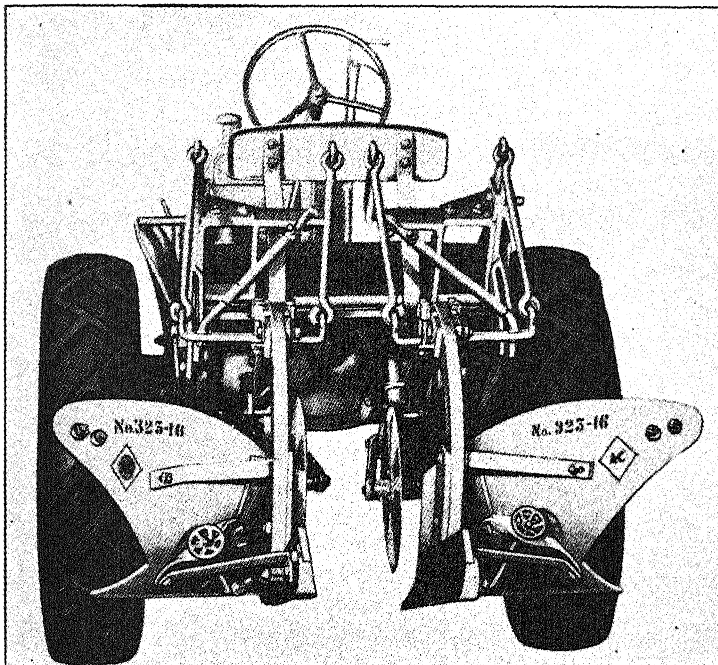


Fig. 24. Mounted, two-way tractor plow.

The direct-mounted, two-way tractor plow operates in the same manner and gives the same advantages as the two-way sulky plow. Direct mounting means a short unit and makes it easy to work out field corners. Narrow headlands are sufficient.

The two-way, turnover plow has two power lifts. When the lift on the left wheel is engaged by pulling the left-hand trip

rod, the plow-wheel axles move backward toward a vertical position, thus raising all the bottoms to a transport position.

When the lift on the right-hand wheel is engaged, the bottoms revolve, that is, the bottoms shown in the raised, idle position revolve until they have taken up the lowered (working) position. There they automatically lock and remain

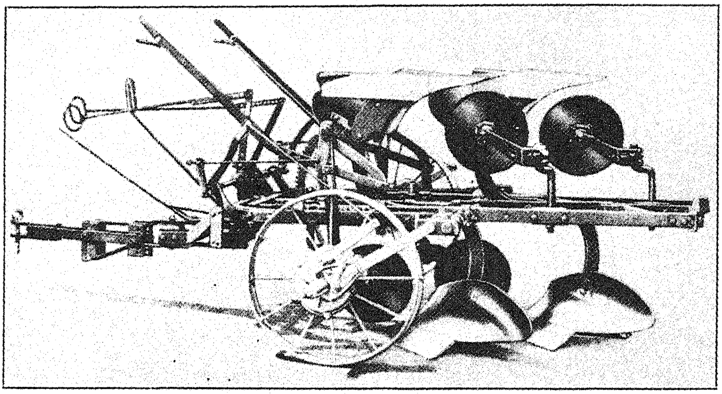


FIG. 25. Two-way turnover plow.

locked in their working position until the right-hand power lift is raised again.

This plow may be operated as a conventional one-way plow, if desired, with only one pair of moldboards used; or the operator may use the right-hand and left-hand pair alternately, thus gaining all the advantages of the two-way plow for hillsides, contour plowing, or strip farming, as mentioned above.

Construction of Tractor Plows

Direct-mounted tractor plows are a recent development and are particularly suitable for use with small farm tractors.

The trailed tractor plow is the older type and was developed from the riding plow.

The construction of tractor plows and of their various parts and adjustments is similar to that of sulky and gang plows.

Much of the information given about sulky and gang plows applies as well to tractor plows.

Heavy beams with diagonal and lateral braces serve as a rigid frame. No separate frame such as that used in riding plows is required. The axles extend across the beams, passing through steel plates or brackets which are bolted to the beams.

Lifting Device. Power is taken from one of the plow wheels and applied to the plow axles, causing them to shift

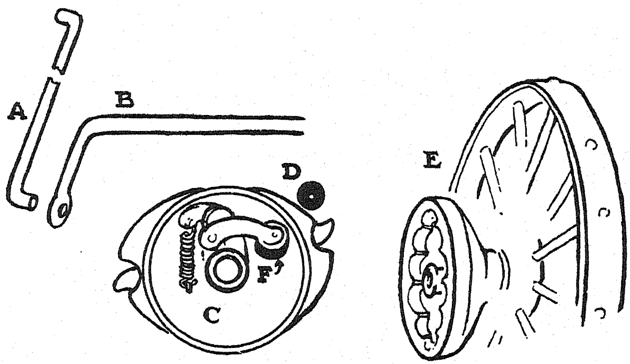


FIG. 26. Tractor-plow lifting device for trailed plow.

backwards toward a vertical position. This backward movement of the axle raises the plow. When the plow is fully raised, with the axles nearly vertical, the power-lift mechanism is automatically disengaged. The reverse action lowers the plow; when the power-lift mechanism is disengaged, the plow axles move toward the horizontal position and the plow is locked in the working position.

The typical power lift shown in Figs. 26 and 27 is essentially a clutch, consisting of two main units. One is a driving unit, the other a driven unit. Here the driving unit is the center, or hub, of the land wheel. This clutch driving wheel (*E*) has driving notches or recesses cast within it. It is made integral with the land wheel and always revolves with it. The land wheel and clutch driving wheel revolve freely on the clutch shaft (*B*), except when the plow is being raised or lowered.

When the plow is lifting, the clutch driving wheel drives the clutch shaft (*B*). Through connection with the lifting link (*A*), the clutch shaft forces the plow beams upward.

When the operator pulls the trip rope, the stop roller (*D*) is withdrawn from its recess; the driving roller (*F*) springs

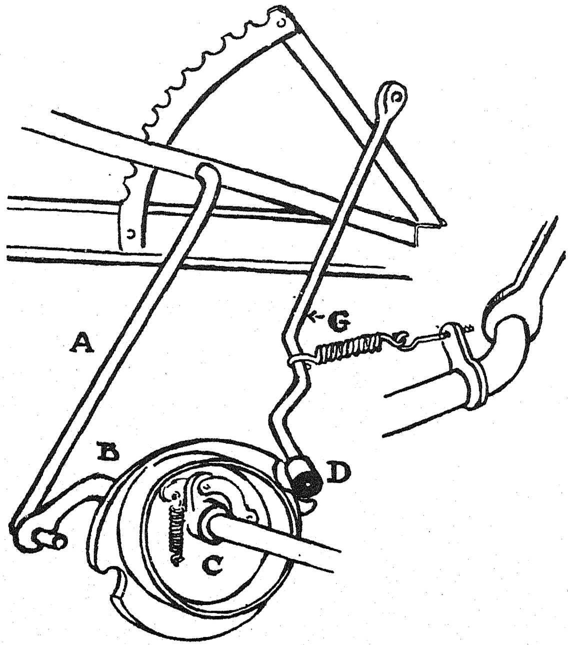


FIG. 27. Parts of the lifting mechanism.

outward, engaging in one of the recesses of the clutch driving wheel. The driving roller (*F*) is carried in the driven plate or drum (*C*), which in turn is keyed securely to the clutch shaft.

The driven plate (*C*) has two recesses. When it has made a half revolution the stop roller (*D*) springs into the second recess, freeing the drive roller (*F*) from contact with the clutch wheel and leaving the land wheel free to revolve on the clutch shaft without driving it.

The motion of the land-wheel axle, as it moves toward the vertical position when lifting the plow, is transmitted to the front-furrow-wheel axle and to the rear-wheel axle also. Thus, all wheels function in the lifting action and the plow is raised high and brought level to its transport position. When in transport, the rear wheel is free to caster, so turns are easily made; but, when the plow is lowered, the rear axle is automatically locked in working position.

As the action of the power lift depends on the revolving of the land wheel, the lifting action must begin while the plows are still moving and trying to maintain their usual depth. Owing to this factor and also to the weight of the furrows on the bottoms, great lifting power is required. To supplement the mechanical lifting action, heavy springs are connected between the beams and actions. These springs tend to pull the axles toward the vertical or lifted position. They are adjustable and, if their tension is increased, lifting is made easier.

The lifting devices for direct-mounted tractor plows either is manual, in which case a long hand lever is assisted by a lifting spring, or is operated by power as described on p. 35.

Adjustment of Tractor Plows

The actual work of plowing is performed almost entirely by two parts, the share and the moldboard. All other parts merely supplement or assist these two.

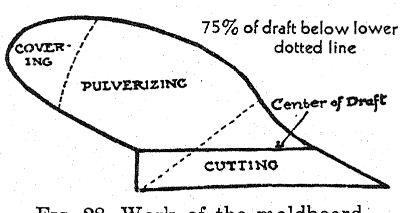


Fig. 28. Work of the moldboard.

Plow adjustments are necessary in order to maintain these two parts at the desired depth and width, and to make sure that the plow bottom moves forward straight and level, always

meeting the soil at the correct angle and speed, with as little land friction as possible.

The work of the plow bottom consists of cutting loose the furrow slice, pulverizing it and inverting it, wholly or partially, so that surface growth and trash may be covered and mixed

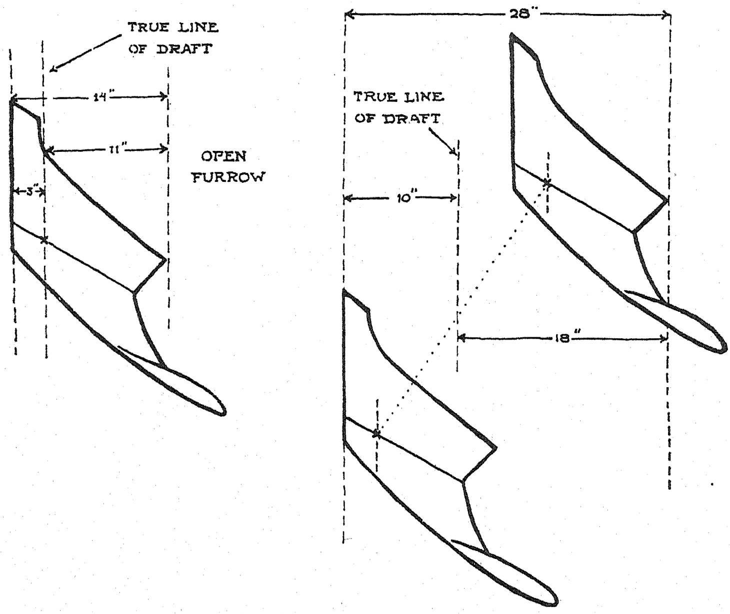


FIG. 29. Center of resistance.

with the soil. The heaviest part of this work is illustrated as being done below the dotted line in Fig. 28. It is estimated that 75 per cent of the power required is consumed below this line.

Center of Resistance. The center of resistance of all the forces acting on a plow bottom, working in its normal position, is considered to be a point just above the junction of the share and moldboard, 2 to 4 inches from the landside edge. This, of course, is not a fixed or definite point. It shifts with variation in the condition of the soil, depth of plowing, type of mold-

board, and other factors. But a study of plow-hitching problems will be easier if it is assumed that the center of resistance is located at or near this imaginary point.

Lateral-hitch Adjustment. The center of resistance, or true line of draft, for a single 14-inch plow is 3 inches from

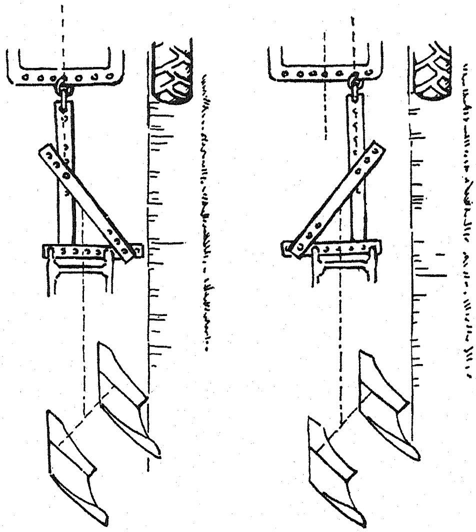


FIG. 30. Plow hitches. *Left*—Side draft on plow. *Right*—Side draft on tractor.

the landside (or furrow wall) and 11 inches from the outer edge of the share (Fig. 29). With two 14-inch bottoms, the center of resistance is approximately 10 inches from the landside edge and 18 inches from the edge of the open furrow. This is about halfway between the two beams. With three 14-inch bottoms, the center of resistance is approximately 17 inches from the landside edge and 25 inches from the edge of the open furrow, or at a point almost directly below the center beam.

This means that the plow bottom will perform its complex functions best and with least waste of power if the center of the tractor can be hooked directly ahead of the center point

of resistance on the plow. If these two centers are not in the same line, *side draft* will exist. This means that the two centers will try to work themselves into the same line, causing a waste of power. Side draft will cause excessive landside pressure, as illustrated in Fig. 30, and difficult steering if

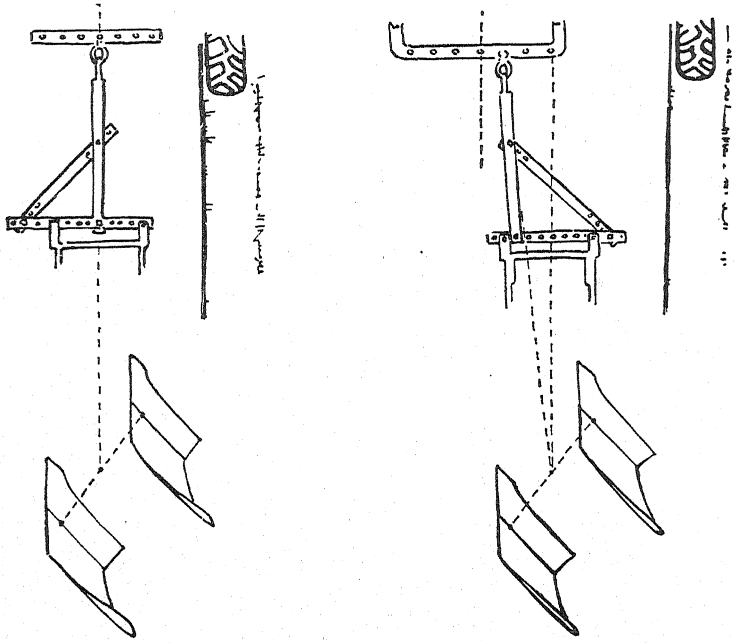


FIG. 31. Plow hitches. *Left*—Ideal hitch, centers of power and resistance fall in the same line. *Right*—Side draft divided between plow and tractor (wide-tread tractor).

the plow drawbar is hooked far from the center of the tractor. Either condition will result in a waste of power. An ideal tractor hitch is possible when the tractor is narrow enough to permit one drive wheel to run in the open furrow, and the center of the tractor drawbar falls exactly in line with the center of resistance of the plow.

But with the wide-tread tractors this ideal condition cannot

exist. For instance, a tractor with a 64-inch tread, if operated with its 10-inch tire in the open furrow, will have its center 8 inches to the left of the center of resistance of a two-bottom 14-inch plow.

The effect of these 8 inches of side draft may be largely overcome by dividing them between the tractor and the plow. To do this, the hitch is connected slightly to the right of the center of the tractor drawbar and slightly to the left of the center-of-resistance line of the plow. (See Fig. 31.) The side draft will be less noticeable if the drawbar between plow and tractor is lengthened.

Drawbar. The drawbar on a tractor plow has the same function as the eveners on a riding plow. It connects the load

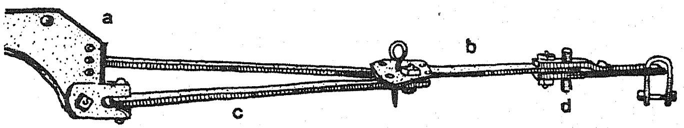


Fig. 32. Tractor-plow drawbar.

to the power and must provide means for the correct adjustment of the hitch, both horizontally and vertically. The various parts of the drawbar connections of a standard tractor plow are shown in Fig. 32, where the vertical adjustment is at *a* and the horizontal adjustment at *b*.

Some means are usually provided in the drawbar for automatically uncoupling the plow if it hits a rock or is obstructed in some other way. This would prevent serious damage to the plow and possible injury to the operator of the tractor. Figure 33 shows a spring release. The coupling that connects to the tractor drawbar is held in place by the coil spring. Unusual pressure or a severe jar will compress this spring to such an extent that the coupling will slip from its retaining clip and allow the clevis (K) to release from the drawbar (L). In the drawbar shown in Fig. 32, a wooden break pin is used for the same purpose.

The Triangular-type Drawbar (Fig. 34). This is commonly used on tractor plows. It makes possible a wide range of adjustments, both laterally and vertically.

Lateral adjustment may be secured in several ways.

1. Shifting the point of connection between the drawbar and drawbar brace (*C*).

2. Shifting the position of the drawbar and brace at the points where they connect to the crossbar (*D*).

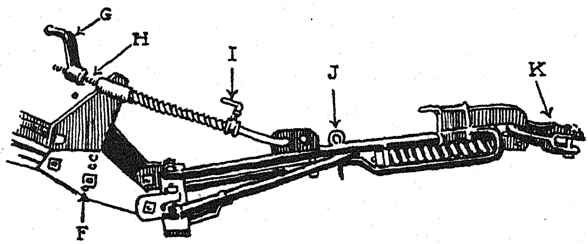


FIG. 33. Drawbar for two-wheel plows with spring release.

3. Shifting the position of the crossbar in the hitch clevises (*E*).

The position of the tractor clevis (*A*) with relation to the center of resistance of the plow is a vital factor in adjusting the horizontal hitch. If the clevis (*A*) is moved to the left, the plow will cut narrower, assuming, of course, that no change is made in the point of attachment to the tractor. Likewise, if the plow drawbar is adjusted to move the clevis (*A*) to the right, the plow will cut wider.

4. The fourth way, and the easiest way to change the lateral hitch, is to shift the connection on the tractor drawbar. Moving this to the right lessens the width of cut, and moving to the left increases the width. Moving this point away from the center of the tractor increases the side draft on the tractor, but, within reasonable limits, the effect of this side draft may not be noticeable.

High-lift Drawbar for Two-wheel Plows (Fig. 33). The length of the stop rod is adjustable by the nut *G*. In working

position a play of about ½ inch should exist at *H* in order to give free action to the plow in uneven soil conditions. When the plow is lifted the stop nut (*G*) comes to rest against the bracket, making a rigid hitch and causing the rear as well as the front of the plow to raise. Tightening the nut *G* will raise

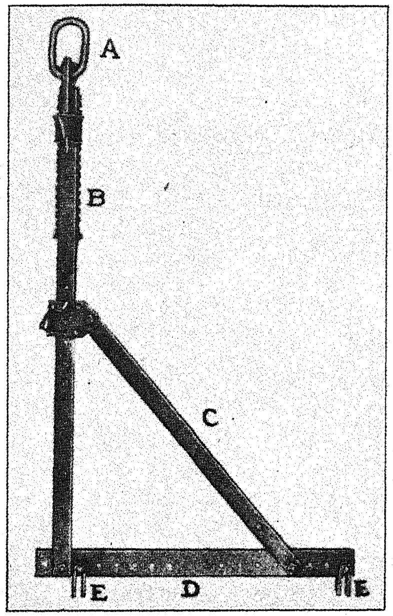


FIG. 34. Triangular drawbar.

the rear of the plow, but the nut should be adjusted so that the front of the plow is higher, when in transport, than the rear.

The collar (*I*) regulates the tension of the compression spring. To increase pressure at the front end of the plow, decrease the spring pressure. To increase pressure at the rear of the plow, increase the spring pressure.

Position of the drawbar brace (also called angling bar) is regulated by the pin *J*. Moving the end of the drawbar clevis

(K) to the right and then replacing the pin (J) will increase the width of cut if the clevis is reconnected at the same point on the tractor.

Vertical-hitch Adjustment. A correct vertical hitch requires that the plow drawbar be adjusted so that it lies in an imaginary line connecting the center of resistance to the tractor drawbar (Fig. 35).

This center point of resistance lies below ground level. Hence the plow drawbar should point downward, from the tractor toward the plow.

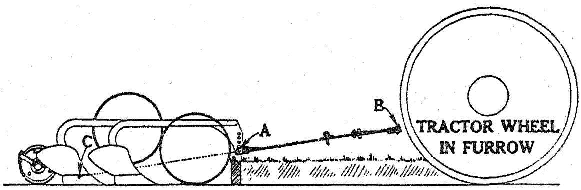


FIG. 35. Correct vertical hitch.

Adjustment may be made at the plow by raising or lowering the connection in the draft plates (A). However, in some cases it may be desirable to adjust the vertical hitch by raising or lowering the tractor drawbar.

A correct vertical hitch will cause the beams to work in a level position (longitudinally) and will distribute the weight equally on the plow wheels, maintaining a slight clearance beneath the heel of the landside, as shown in Fig. 17.

Too high a connection at A makes the plow run on the point of the share, causing unnecessary wear and unsteady operation of the plow, owing to its tendency to lessen rather than increase the vertical suction.

If the hitch is too low at A, or if the tractor drawbar is too high, the upward pull on the front of the plow may be so great that it prevents proper penetration and causes excessive pressure on the rear of the plow. This condition, however, is rarely encountered. A low hitch at A is desirable and gives the

best results and the easiest draft. Observation of many plow shares indicates that they wear out by running too much on the points, wear that might be reduced if the vertical hitch were lower at A (Fig. 35).

The vertical hitch on drawbars, such as shown in Fig. 33, is adjusted by means of the series of holes at F.

Adjustment of Rear-furrow Wheel. The setting of this wheel controls the pressure between the heel of the landside and the bottom of the furrows, as well as the pressure between the landside and the vertical side wall of the furrow. Pressure or friction at these two points should be as light and should be carried on the furrow wheel as much as possible to reduce friction.

Lowering the wheel increases the clearance indicated in Fig. 17, and setting it in (toward the land) increases the clearance between the landside and the furrow wall as indicated in Fig. 18.

Two-wheel tractor plows usually have the heel of the landside widened and, reinforced as with no rear wheel, the landside must press against the bottom of the furrow.

The rolling landside (Fig. 6) often used on two-wheel plows, is sometimes rigidly fastened to the beam and will give the correct clearances until its diameter is lessened, owing to wear, or the bolts retaining it become loose. In modern plows, provision is made for adjusting the rolling landside in much the same manner as the rear-furrow wheel.

Coulter and Jointer Adjustment

The various parts of the coulter and jointer assembly are shown in Fig. 36. These parts usually provide means for four distinct adjustments.

Coulter Adjustment. *Fore and Aft.* The hub of the coulter usually is set approximately above the share point. But in hard ground, better penetration will be secured if the coulter is moved further back, so that the hub is behind the share

point. For this adjustment, two or more sets of holes are provided, or the coulter shank may be clamped to the beam at any desirable location. Moving the coulters well forward may cause better scouring.

Depth or Vertical Adjustment. This is obtained by raising or lowering the coulter shank in the beam clamp. (See Fig.

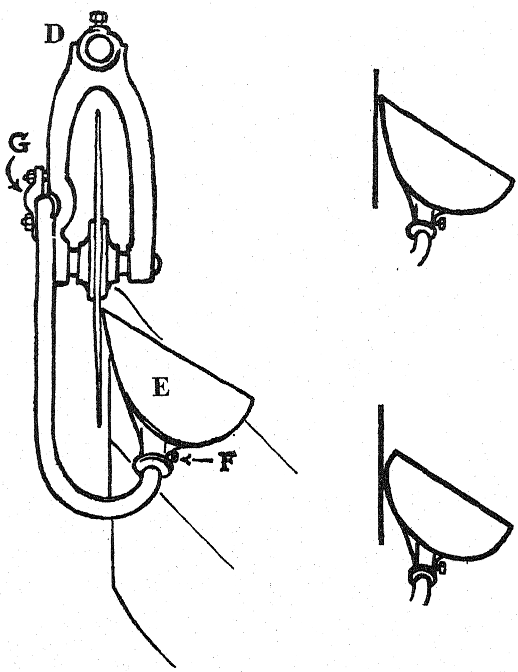


FIG. 36. Coulter and jointer adjustment.

22.) The coulter should be deep enough to cut through surface trash, stubble, or roots and leave a clean, sharp, furrow wall. This usually requires that the bottom of the coulter blade be about 2 inches above the share point, although for deep plowing it should be higher.

Landing the Coulter (Lateral Adjustment). To obtain a sharp furrow wall which is not crumbled or broken, the coulter should travel ½ inch or more to the left (or landside)

of the plow bottom (Fig. 36). The exact distance varies with the type of soil; a wider setting is required for loose, crumbly soils than for sod.

Adjustment is made by loosening the coulter shank in the clamp and turning it until the offset at the lower end moves in or out, as desired (Fig. 22). The top end of the coulter shank is square, so that a wrench may be used for this purpose.

Swing of the Coulter. The set collar (Fig. 36*D*) which retains the coulter on the shank is provided with stops, which limit the swing of the coulter when the plow is raised. This should be set to allow the coulter to swing an equal distance toward either side of the share point. Then the coulter can pivot when the plow is turned to the right or left.

In addition, if set in this manner, the coulter will act as a caster when in the working position and will always follow a course exactly parallel to the line of travel of the tractor. Thus, it indicates the true line of draft. If the plow is correctly hitched, the beams will be parallel to the line of travel of the coulter.

Jointer Adjustment. The shank carrying the jointer is clamped to the coulter yoke (Fig. 36). Provision is made for two adjustments.

1. *Depth.* Jointers should be set deep enough so that the whole surface of the jointer moldboard is scoured by the turning soil. If only a portion of this miniature moldboard is in use, the jointer should be set more deeply. If soil overflows the jointer moldboard (*E*), it should be set more shallow. From 1½ to 2 inches of depth is usually needed.

Depth may be adjusted at the clamp (*G*) and, in some cases, also at the point where the jointer is secured to the shank (*F*).

2. *Adjustment of Jointer Point.* The jointer point should almost touch the coulter blades. Back of the point ample clearance is needed in order that trash or stubble may not wedge between the jointer point and coulter blade. (See Fig. 36.) Adjustment for this setting is made at the clamp (*G*). Tak-

ing up the forward clamp bolt more than the rear bolt brings the jointer point toward the coulter blade. Sometimes this adjustment may be made with the setscrew (*F*).

Worn jointer points should be restored to the original wedge shape by grinding or should be replaced with new points.

Rigid Jointers. Rigid, or independent jointers (Fig. 38) may be used in combination with the rolling coulter as is the case with walking plows. Jointers alone may give a good job of covering trash, but the draft reducing effect of the rolling coulter is lost.

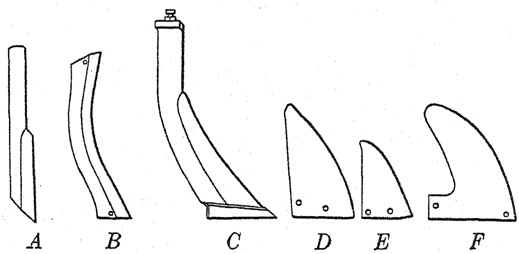


Fig. 37. Knife coulters. *A*—Hanging. *B*—Quincy. *C*—Duck-billed. *D, E, F*—Fin cutters.

The necessary adjustments are similar to those required for the rolling coulter and may all be made at the clamp which attaches the jointer shank to the beam.

1. The depth should be 1½ to 2 inches, or sufficient to bring the whole jointer moldboard into action.

2. The point should be set about ½ inch to the landside of the share point.

3. The pitch or angle at which the jointer meets the soil should be regulated to permit the jointer to scour freely and to turn its miniature furrow well.

Knife Coulters (Fig. 37). For certain conditions such as new ground, brush land, heavy sod, rocky ground, etc., various types of knife coulters are available.

1. The hanging cutter is set with the point about 1 inch above the share point and angled backwards as shown.

2. The Quincy cutter, a double-end knife, bolts to the beam and side of the share. It is used largely on walking plows.

3. The duck-billed, or brush, type attaches to the beam and to the point of the share, thus relieving the share point from much severe wear. It is used on breaker-type tractor plows.

4. The fin cutter is a sharp steel blade bolted to the landside of the plow bottom and is used primarily for sod plowing.

Plow Accessories

Hillside Plowing. To prevent the plow from sliding downhill and to maintain correct width of plowing, a landing lever is desirable. This may be furnished as an attachment for the plow or for the tractor. With the tractor, the drawbar (swinging type) may be adjusted laterally as desired.

Trash Covering (Fig. 38). For difficult conditions such as the plowing under of a heavy surface growth or a dense accumulation of trash or stalks, where particularly thorough covering is required as in the control of corn borer, special attachments may be desirable.

A wide furrow will give better covering, and hence an 18-inch bottom gives better results than a 14-inch.

Well-sharpened coulters, 18 inches in diameter, will cut through the surface trash thoroughly, reducing it to lengths which may be turned and covered by the moldboard.

Independent jointers with moldboards of ample size, accurately adjusted so that the entire surface of the jointer moldboard functions in turning its miniature furrow, will improve covering.

Trash springs or wires, attached as shown in the illustration, press down the trash or stalks and enable the furrow slice to bury them more effectively.

The notched coulter seems to give better results than the plain coulter in cutting through heavy trash. It may be secured in 18-inch size.

Weed hooks attached to the plow beam also help in covering trash.

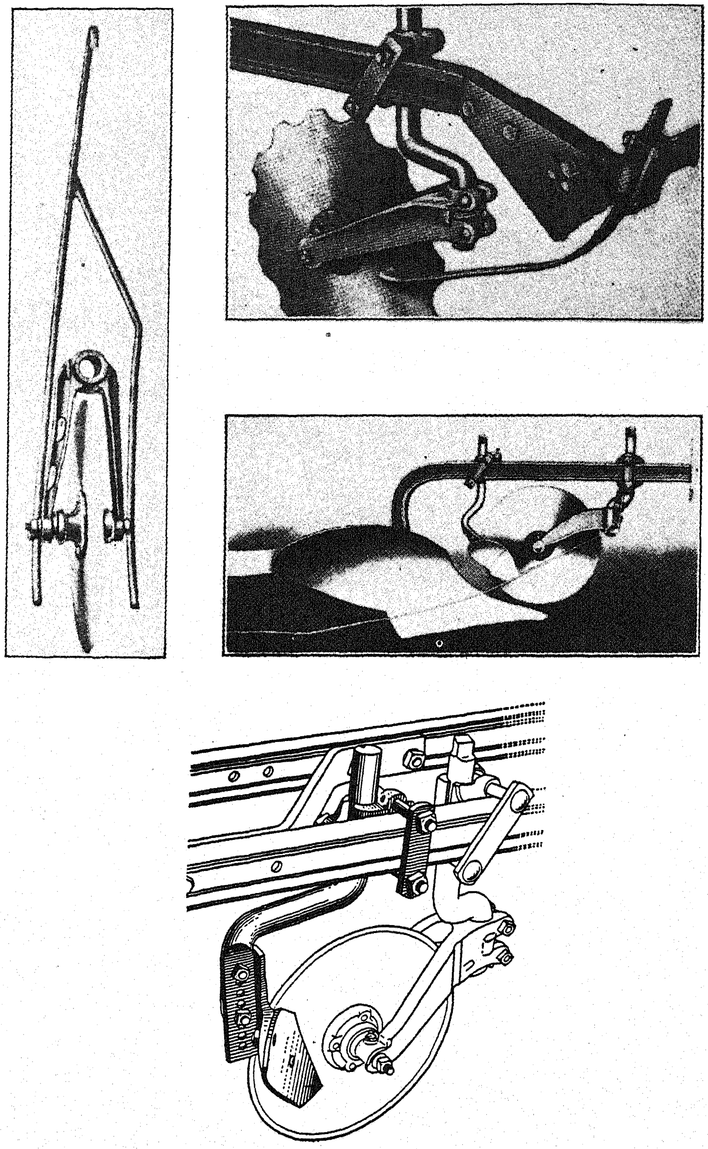


FIG. 38. Trash covering accessories.

Rocky Ground. Crucible-steel shares are best for use in rocky or stony land unless the soil is of a quality to cause difficult scouring.

The plow should be connected with a spring release which can be easily recoupled from the tractor seat. Tension of the release spring can be adjusted to suit the field conditions.

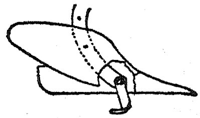


FIG. 39. Shock shoe.

A shock shoe, attached to the plow bottom as illustrated, cushions the fall when the plow is dropped on rocky ground. This is especially desirable when chilled cast-iron bottoms are being used.

A tractor stop hitch is available for use on rocky ground or stump land. It is designed with a sliding drawbar and, when an obstruction is encountered, the clutch pedal is thrown out and the tractor automatically stopped without disconnecting the plow from the tractor.

To recouple, the tractor is backed up and the clutch-throw-out mechanism reset from the tractor seat. This equipment is more convenient than the release spring on the plow and is best for use under severe conditions.

JOB 3

TO REPAIR A TRACTOR PLOW

Procedure

1. Get information from the owner on the condition of the plow, year of purchase, field troubles, faulty adjustments, missing or worn parts, etc.

2. Inspect and test the implement thoroughly. Note all information received from the owner and the results of your inspection. Time spent in organizing your work is well spent. It will help in preparing the list of repairs needed and will make possible an estimate of the cost of such parts.

3. Order repair parts. For quick service in obtaining repair parts, it is necessary to give an accurate and complete description of the parts needed. The dealer or agent should always be given the following information:

(*a*) Name and catalog number of the parts wanted.
(*b*) Size or model of the implement.
(*c*) Serial number of the implement (if possible).
(*d*) Name of manufacturer.

Example of Order for Repairs*

1 Lifting wheel lug—LTP-175
1 Hub cap—N311
1 Clutch throwout arm—HTP-7
2 Plunger springs—LTP-31

* All above parts for Allis-Chalmers 2-bottom, 14-inch tractor plow, No. 2 Series (2-214).

In addition, the dealer should be advised how the parts are to be shipped—by freight, parcel post, express, etc. Sometimes a cipher code is used for ordering parts by telegraph. If so, the cipher words are listed in the repair catalog. The cipher word replaces the catalog number and name of the part.

In ordering repairs it is sometimes necessary to state whether the repair part is for the left or right side of the implement. The right or left side of an implement is expressed when one faces in the direction the implement moves.

To order repairs properly, it is necessary to have a repair catalog always available. The serial number and the model designation are usually stamped on a brass nameplate, or stamped or molded directly on some part of the machine.

4. Take apart the power-lift assembly. Clean all parts and inspect for wear; test tension of the springs in drive-roller assembly and trip lever (Fig. 27*C* and *G*); test for wear between clutch plate and shaft (*B* and *C*). Lost motion here is serious.

5. Remove bottoms from the beams. Inspect bottom bolts and frog.

6. Paint the plow while it is disassembled and awaiting repair parts. Painting is convenient then; wheels should be painted while they are mounted on a short piece of pipe held in a vise. All inspections should be made before painting.

7. Compare the repair parts received with the old parts to make sure they are correct replacements.

8. Reassemble the repair parts and perform all necessary

repair operations. Definite rules for procedure are difficult as requirements may vary. But a typical plow repair job usually includes the following operations:

(*a*) Sharpening or replacing shares.
(*b*) Replacing landside (if required).

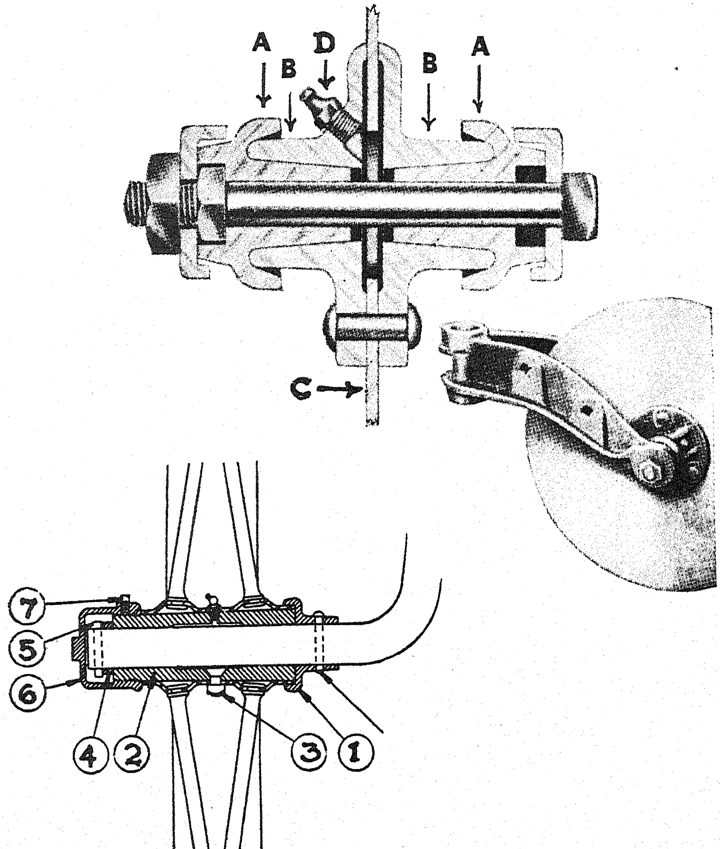


Fig. 40. Coulter bearings and wheel box.

(*c*) Restoring beam alignment. (See p. 20.)
(*d*) Tightening all plow-bottom parts; polishing moldboards; securing flush, even joints between surfaces

making contact with the soil; using the correct type of plow-bottom bolts.

(*e*) Replacing worn wheel boxes and adjusting wheels on axles (see Fig. 40); adjusting rear-furrow wheel as indicated in Figs. 17 and 18.

(*f*) Tightening or replacing axle brackets.

(*g*) Sharpening coulter blades.

(*h*) Replacing coulter bearings. (See Fig. 40.)

(*i*) Regrinding or replacing jointer points.

(*j*) Adjusting coulters and jointers.

(*k*) Adjusting rear-wheel scraper (if soil accumulates on the rear wheel and increases its diameter, the plow bottoms are thrown out of adjustment).

(*l*) Repairing and adjusting power lift.

(*m*) Repairing and adjusting levers.

(*n*) Straightening drawbar parts, replacing bolts and clevises and adjusting release mechanism.

(*o*) Replacing lubrication fittings and grease cups (as needed).

(*p*) Lubricating all bearings.

(*q*) Greasing all polished surfaces to prevent rust; painting other parts.

JOB 4

TO STUDY THE CHARACTERISTICS OF GOOD PLOWING—TO JUDGE PLOWING

Procedure

The score card which follows indicates fairly well the relative importance of eight necessary qualities of good plowing. A plowed field that has mellow or old ground should be selected for this study. The judging should be done soon after the plowing is completed, as the various features mentioned in the score card stand out better when the plowing is fresh.

	Per Cent
1. Furrows straight from end to end	10
2. Back furrow slightly raised and all trash covered	10

	Per Cent
3. Ground thoroughly pulverized from top to bottom of furrow: no air spaces left in plowing*	20
4. All trash and surface growth completely covered	20
5. All furrows of equal depth and width	10
6. Dead furrows free from unplowed ground	10
7. Furrow crowns even: level-appearing field	10
8. Proper and uniform depth in plowing headlands	10

* This rule does not apply on sod or new ground.

Straight furrows depend to a great extent upon the skill of the driver. Even with an experienced driver, however, a plow that does not penetrate properly may result in crooked furrows. Lack of penetration causes the plow to swing to one side or to the other, and not to follow directly behind the power drawing it. Improper hitching gives the same result. Plow hitches and the causes of lack of penetration will be discussed later in this chapter. Crooked furrows make it very difficult to plow out all the ground in the dead furrows, and also result in poor covering of surface growth.

Plowing is usually begun in a field by striking out a back furrow. Most moldboard plows are right hand, that is, they turn the furrow toward the right. The plow is drawn across the field, turning over the furrow to the right. At the end of the field the plow is removed or raised from the ground; the operator turns the implement around and plows back again across the field. The plow turns this furrow also toward the right. In other words, the furrow plowed on the return trip is turned against the one plowed on the first trip across the field

The furrows thus turned are referred to as a back furrow. The top or crown of the back furrow (where the two furrows meet) may be slightly higher than other furrow tops. There should be no trash or grass showing through the back furrow.

The amount of pulverization depends upon the shape of the moldboard, the speed at which the plow is drawn, and the condition of the soil. The speed is not subject to much variation except with tractor plows. With tractors, second or third speed is used, giving a forward speed of 3 to 5 miles per hour.

First or low speed, which results in less pulverization, may be used where plowing conditions are difficult.

If the correct type of plow bottom is used and the plow penetrates well, good pulverization will be secured.

The plow should leave the soil fine and mellow. Clods and air spaces in the plowing are objectionable.

Trash and surface growth should be completely turned under. Weed hooks are helpful in turning under a heavy growth of trash. The combination coulter and jointer, if properly adjusted, will give good covering under most field conditions. (See Fig. 38.)

Furrows should be of equal depth in all parts of the field. This rule, of course, must be modified in fields where the subsoil is nearer the surface in some parts than in others. Very often only one depth adjustment may be made for the entire field. In some fields, however, it is necessary to change the depth adjustment frequently. Some spots are hard, while others in the same field are soft.

A dead furrow is the open ditch or trench which occurs when adjacent furrows are thrown in opposite directions. In large fields where several back furrows are required, dead furrows cannot be avoided if the conventional type of moldboard plow is used. To lessen soil washing and erosion, plowing on hillsides and slopes should be planned to make the dead furrows fall on the contour.

The dead furrow should be made rather shallow, but no unturned ground should be left in it. Plowing out or finishing up the dead furrows is sometimes difficult. It is especially troublesome if furrows in the main parts of the field are not straight.

Careful driving is necessary to secure uniform width of furrows. This is true with both horse-drawn and tractor-drawn plows. The plow must be drawn so that each plow bottom cuts the same width. With gang plows or tractor plows it is necessary to adjust the hitch carefully so that the front plow will cut as wide a furrow as the rear plow (or plows). If it does

not cut the proper width, the top or crown of this furrow will not be level with the others, and each successive trip across the field will be marked by this one uneven furrow top. In good plowing, all the furrow tops are of even height.

Headlands, or strips of ground to turn around on, are left at each end of the field. With horse-drawn plows, the headlands need not be very wide, but tractor plows require larger ones. A convenient width of headland for a two-plow tractor (with trailed plow) is 25 feet. Headlands are left on all four sides of the field. The last step in finishing the field is to plow the headlands. This is usually done by plowing clear around the field without removing the plow from the ground. The ground in the headlands gets packed and hard from the turns made on it when the main part of the field is being plowed. It is sometimes necessary, for this reason, to set the plow deeper when plowing the headlands. All the ground in the headland should be plowed, none missed. Direct-mounted tractor plows eliminate the need for wide headlands.

JOB 5

TO "LAY OUT," "OPEN UP," AND PLOW A FIELD WITH A TRACTOR PLOW

Many factors should be considered in planning the plowing. Idle travel and travel on the fresh plowing should be kept to a minimum. Field corners and headlands should be plowed as completely as possible. Unnecessary back furrows and dead furrows should be eliminated, unless special conditions make them desirable; on hillsides or slopes they should follow the contour. Plowing should level the field; this may require crossing the previous year's plowing. Thorough trash covering is important.

Description of Operations (for Plowing a Rectangular Field)

1. Set the plow to penetrate very lightly. With the plow set just deep enough to make a deep scratch (called the *scratch furrow*), drive across one edge of the field, making a mark

parallel with the edge of the field and about 25 feet in from the edge.

Make similar marks on all four sides of the field. When completed, the scratch furrow should extend clear around the field, parallel with the sides. The 25-foot space thus left at each edge of the field is called a *headland*. Narrower headlands may be left when using walking plows or mounted tractor plows.

2. Starting where the scratch furrows intersect at one corner of the field, measure or pace in about 60 feet and set up a stake for a mark. Set up another marking stake opposite the first at the other side of the field 60 feet in from the corner where the scratch furrows intersect. These two stakes indicate a straight line across the field (Fig. 41*A* and *B*).

3. Drop the plow into its working position exactly on one of the stakes. Plow straight across the field toward the second stake.

Lift the plow from the ground when the scratch furrow at the second stake is reached. Turn around to the right, pull back to the scratch furrow, and drop the plow again exactly on the scratch furrow.

The plow should now be in such a position that its return trip across the field will throw the furrows back against those plowed on the first trip. This forms the back furrow.

4. When opening the back furrow with wheel plows, the front-furrow wheel must be raised higher than it is after the back furrow is completed. After this it runs in the bottom of the open furrow, hence it must be set lower. Completing the return trip, or second half, of the back furrow requires care and good judgment. If the tractor is driven too close to the first furrows, the completed back furrow becomes a high ridge; if driven too far from the furrows, surface growth and trash will be left uncovered at the center of the back furrow.

5. Adjust the horizontal hitch so that the front plow will cut the correct width of furrow, and get the center of power and center of resistance as nearly in line as possible. (See p. 39.)

6. Adjust the vertical hitch as described (p. 44).

7. Check the adjustment of coulter and jointer.
8. Adjust to the desired depth with depth lever.

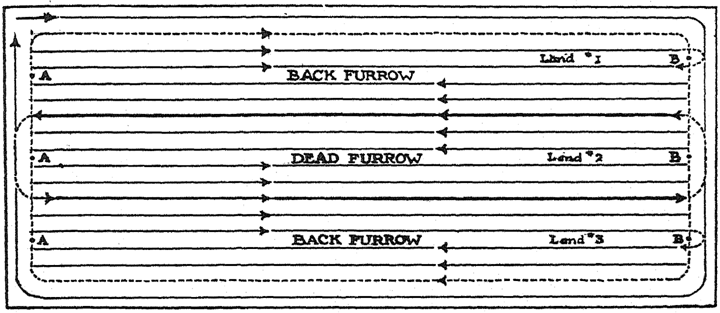


FIG. 41*A*. Method for plowing a large rectangular field.

9. Level the plow laterally with the leveling lever. The plow may be leveled longitudinally (lengthwise) by the setting of the vertical hitch on the plow, by vertical adjustment of the

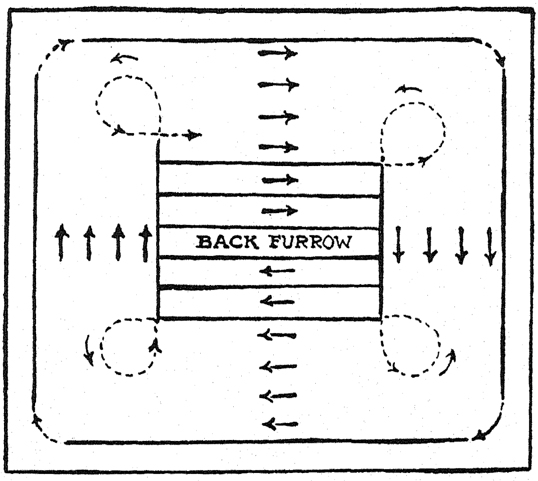


FIG. 41*B*. Method for plowing a small rectangular field.

tractor drawbar, and by vertical adjustment of the rear-furrow wheel.

10. Plow back and forth around the first back furrow. Raise the plow each time the scratch furrow at the ends is reached, turn around to the right, and drop the plow again exactly on the scratch furrow.

11. When the plowed strip has widened until it reaches the scratch furrow from which the distance to the stakes was measured, lay off another strip to be plowed in the same manner. The back furrow for this strip will be 60 feet from the edge of the plowing. This is 120 feet from the first back furrow. These strips are called *lands*. It is necessary to have more than one strip, or land, on large fields; otherwise a great deal of time would be wasted in traveling across the ends of the plowed strips. The lands should be as nearly equal in width as possible.

Where each new land is opened, a *back furrow* is formed. At the finishing point, a *dead furrow* is formed between two lands.

This basic method may be easily modified to reduce the number of back furrows and dead furrows. After the first land is completed (Fig. 41), it is usually desirable to skip the adjoining land (2) and start plowing again by making a back furrow at the center of land (3). If lands are made 120 feet wide, this back furrow will be 180 feet from the edge of land 1. Plow out from the back furrow in land 3 until the plowed strip is 120 feet wide.

Then plow out the center land (2) by plowing along the edge of land 3 and back along the edge of land 1, as indicated by the arrows in Fig. 41. A dead furrow will exist at the center of this land as indicated.

A method for plowing small, rectangular fields is shown in Fig. 41*B*.

12. Plow the headlands after all the main body of the field is finished. This may be done by plowing clear around the field without raising the plow from the ground.

Equal space is left on all sides when the field is laid out.

If the trip around the field is started at the scratch furrow,

the dirt will be thrown in, and the dead furrow will be left at the extreme edges of the field. If the trip around is started at the extreme edges of the field, the dirt will be thrown out and a dead furrow will be left where the scratch furrows were. It is a good plan to alternate each year the direction in which the headlands are plowed.

Field Troubles

The more common field troubles encountered in plowing are listed below with their causes and remedies.

Plow Does Not Scour. This means that the soil sticks to the moldboard, instead of shedding or slipping off properly. This condition results in very poor plowing. The furrow crowns are not even, and the soil turned over by the plow is not well pulverized but is lumpy, cloddy, and full of air spaces.

The principal causes of this trouble are discussed in the paragraphs that follow.

Varnish Has Not Been Removed from Moldboard and Share. All polished parts of the plow bottoms, coulters, and jointers were varnished at the factory to prevent rust. This should be treated with varnish remover, or a mixture of 1 small can of common lye to ½ gallon of water. Apply the mixture with a swab of cloth or waste; let it stand a few minutes and then wipe off. Repeat if necessary. Then, in order to secure a good land polish, operate the plow at high speed and at shallow depth, even though the land need be replowed later at proper depth.

Wrong Material in Plow Bottom. Sticky or heavy soils or soils with a large amount of clay require soft-center-steel moldboards.

In the lighter, sandier soils, moldboards of chilled cast iron scour better than those of soft-center steel. Select the moldboard best suited to the locality.

Improper Hitch. Either the vertical hitch or the horizontal hitch, if improperly adjusted, may cause scouring trouble. The

soil must strike the moldboard at the proper angle to shed off properly. Change the hitch so that the plow is drawn straight and runs level.

Indications of Imroper Hitching

1. Broken or crumbled furrow wall.

Note. This trouble may also be caused by the coulters' being set in too close to the shin of the moldboard.

2. Dirty furrow bottom (also caused by wrong coulter adjustment or wrong hitch).

3. Line of travel of coulters and line of travel of beams not parallel.

Note. The coulters swing freely. Hence they are always drawn straight forward and always indicate the true line of draft. The horizontal hitch of the plow should be adjusted so that the line of travel of the beams is parallel with that of the coulters.

4. Furrow bottom ragged or "gouged."

Note. This indicates that the vertical hitch is too high at the plow. The plow is pulled up at the rear and is riding on the point.

5. Wheels "float" (a wheel rises from the ground and stops revolving).

Note. This may be caused by either too high or too low a vertical hitch. Too low a vertical hitch at the plow pulls the front of the plow upward and relieves the front-furrow wheel of any weight, with the result that it floats.

Too high a vertical hitch pulls the rear of the plow up. The plow then rides on the front wheel and bottom and not on the rear wheel, hence the rear furrow wheel floats. The land wheel may float due to hard ground, poor penetration or worn shares.

6. Uneven furrow crowns. Sometimes it will be noticed that each alternate furrow crown is low (with two-bottom plows), or every third furrow crown is low (with three-bottom plows). This is caused by the front plow's cutting less ground (narrower or shallower furrow) than the rear plow.

If the first-furrow crown is high, it indicates that the front plow is cutting too much ground (too wide or too deep a furrow).

Soil Too Wet. In many localities it is impossible to plow soon after a rain. The soil becomes so sticky that it will not scour off the moldboard. Under these circumstances, plowing must be delayed until soil conditions are suitable.

Rusty Moldboard. Rust on the moldboard is a common reason why the plow does not scour. Soil particles stick to the pits caused by the rust.

The remedy is to scour off the rust. This may be done quickly by plowing in a sandy field. If such a field is not available, the rust must be scoured off with an abrasive material such as emery.

Soft Spots on Moldboard. Moldboards are sometimes faulty, small spots on their surfaces being softer than the adjoining material. Such spots may be detected by drawing a file across the surface of the moldboard. The file will slide over the hard surface easily but will stick slightly on any soft spots. If such spots are found, the moldboard must be replaced with a new one.

Coulter or Jointer Set Too Close to the Shin of the Moldboard. This relieves the shin of the moldboard of practically all soil pressure, with the result that the soil sticks to it. Set the coulter further toward the land.

Plow Does Not Penetrate Properly. The causes of this trouble are as follows:

(*a*) Worn or improperly shaped shares (no vertical suction).
(*b*) Vertical hitch too high or too low.
(*c*) Gauge wheel set too low (walking plows only).

NOTE. If set too deep, the coulter or jointer carries so much of the weight that it practically supports the plow. If set too far forward, it prevents the plow from sucking into the ground.

(*d*) Coulters or jointers set too deep or too far forward.
(*e*) Tractor speed too fast.

Furrow Wall Crumbled or Furrow Bottom Dirty. This usually occurs because the coulters are set too near the shin of the plow. In some soils it is necessary to set them as much as 1½ inches toward the land. A crumbled furrow wall and a dirty furrow bottom may also result from a poorly adjusted horizontal hitch.

Plow Lifts Very Hard. Tighten the lifting spring.

Plow Enters the Ground Very Slowly. Loosen the lifting spring.

Power Lift (Tractor Plow) Does Not Operate Properly. The land wheel operates the power lift. In order to lift the plow, this wheel must have good traction. It is often provided with small lugs for this purpose. Considerable pressure must be carried on the wheel, however, in order that it may have the necessary grip on the ground.

Anything that lessens the pressure carried on this wheel has a tendency to retard or hinder the action of the power lift. Worn shares or a wrong vertical hitch may lessen the pressure and make the power lift fail to function. Too loose a lifting spring may also cause the trouble, as may worn rollers or springs in the power-lift clutch.

CHAPTER II

HARROWS

Harrows are important tillage implements and a necessary part of farming equipment. They are used for many purposes, on various types of fields, and at different stages in the production of crops. Their chief use is supplementing the work of the plow, pulverizing, leveling, smoothing, and compacting the seed bed. Some harrows are used for weed control on fallow ground and in orchards and, to a limited extent, as weeders or cultivators for growing crops.

Under some conditions the spring-tooth and the disk harrow are used instead of a plow for preparing the seed bed. Disk harrows are often used before plowing. They cut up stalks or stubble and enable the plow to distribute such material uniformly through the seed bed, covering it more completely.

Harrows are sometimes used to cover seed broadcast on the field. Seeding attachments may be mounted on certain types of harrows.

Because their work varies so greatly, many different kinds have been developed. Each type is particularly well adapted for certain field jobs.

Spike-tooth Harrows

The spike-tooth harrow is made in sections that are 4 to 5 feet in width. The number of sections used depends upon the power available. It is constructed so that more sections can be added.

The chief use of the spike-tooth harrow is smoothing the seed bed after plowing. If the ground is mellow, it pulverizes and levels well. The many teeth break up the clods and lumps left by the plow, compact the soil, and fill up the air spaces.

The finely pulverized surface left by the harrow forms a mulch, which retards the evaporation of moisture from the soil.

The spike-tooth harrow is often used for killing weeds. For this purpose, it is run over the ground after the crop has sprouted, the teeth being set lightly. Weeds that root near the surface are torn out and destroyed, without injuring the growing crop. The spike-tooth harrow is also used for covering seeds that have been broadcast on the surface of the ground.

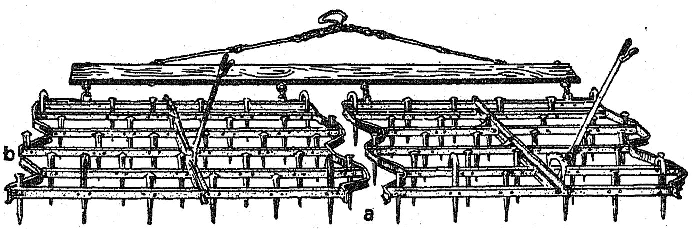


FIG. 42. Two-section spike-tooth harrow.

It is difficult to use on fields that have trash, vines, or stalks on the surface. On such fields the teeth become clogged with trash which raises them out of the ground and prevents their working properly. Frequent stops to clean the harrow are necessary under such conditions. This implement does not penetrate well on hard, stony fields, and it is not particularly good for harrowing sod ground.

The draft of the spike-tooth harrow is light. It requires only about a 30-pound pull per foot of width under normal field conditions. Therefore, it is furnished in wide units and accomplishes its work rapidly.

Construction and Principal Parts

Teeth. The teeth are made of steel and are shaped as shown at *A*, *B*, and *C* (Fig. 43). The head of the tooth is enlarged so that the tooth will not be lost if it becomes loose. All the edges of the tooth are sharpened so that, by shifting

the tooth, a new cutting edge can be obtained. The teeth are fastened to the tooth bars (Fig. 44*A*, *B*, and *C*), six teeth usually being placed on each bar. A harrow of five bars would, therefore, have thirty teeth. (Sections are also made with twenty-five, thirty-five, or forty teeth.) The teeth are so

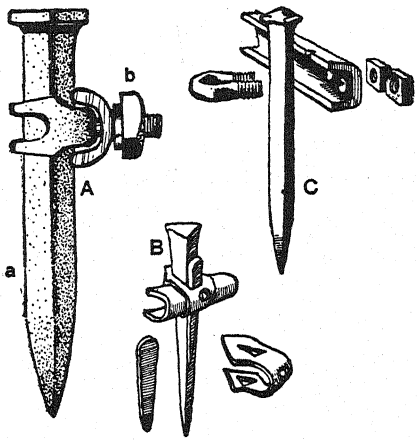


FIG. 43. Three common types of harrow teeth and tooth clamps.

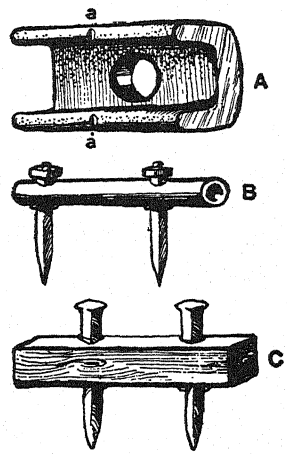


FIG. 44. Tooth bars.

placed on the tooth bars that no one tooth is directly behind another. In a 5-foot harrow section with five tooth bars, every 2 inches of ground is cut by a tooth.

Tooth Bars. The tooth bars are made of wood or steel. Wooden tooth bars are usually square. Steel bars are made in many different shapes, including round-pipe, flat-bar, channel-bar, and U bar. A round-pipe tooth bar is shown at *B* and a wood tooth bar at *C* (Fig. 44). The teeth are attached to the tooth bar.

Tooth Clamps. The tooth clamp fastens the tooth to the tooth bar. Various types of tooth clamps are used. A strong, well-designed tooth clamp is necessary, as there is a severe

strain on the teeth when the harrow is in operation and they must be securely fastened and kept tight. The clamp shown at *A* (Fig. 43) is drawn tight by the nut (*b*), which is locked in place by a spring washer. The edge of the tooth is drawn into a notch in the tooth bar.

Runner Teeth. Runner teeth, shaped as shown at *A*, *B*, and *C*, in Fig. 45, are placed at the four corners of the section. When the harrow is being transported to or from the field, the teeth are slanted back until the curved parts of the runner teeth bear on the ground.

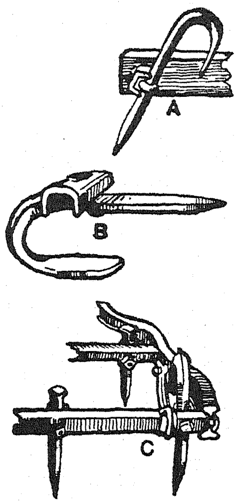


FIG. 45. Runner teeth.

Guard Rails. The ends of the tooth bars in the harrow section shown in Fig. 42 are closed, and the tooth bars pass through the guard rails (*b*). Such harrows are called *closed-end* types. Harrows that do not have the ends of the tooth bars closed in this way are *open-end* types. The guard rails strengthen the construction and make the harrow more rigid. They also prevent the ends of the tooth bars from catching on obstructions in the field.

Corner Braces. The corner braces are shown at *C* in Fig. 45. They are placed at two diagonally opposite corners, one brace in front and one behind. Such braces add greatly to the strength of the harrow.

Levers. One lever is usually provided on each section with which the teeth are set to penetrate to the depth desired. Modern construction permits the levers to be placed either at the front, or at the rear of the section. If the harrow is drawn directly behind the tractor, front placement is the most convenient. But if the harrow is trailed behind a grain drill,

plow, or other implement, the levers are more easily accessible if placed in the rear of the harrow section. Figure 46 shows how the angle of the teeth is controlled by the lever (*b*) and the lever ratchet (*c*). The ratchet has a series of notches in which the lever may be set, thus providing a wide range of adjustment. The lower end of the lever is attached to the rocker

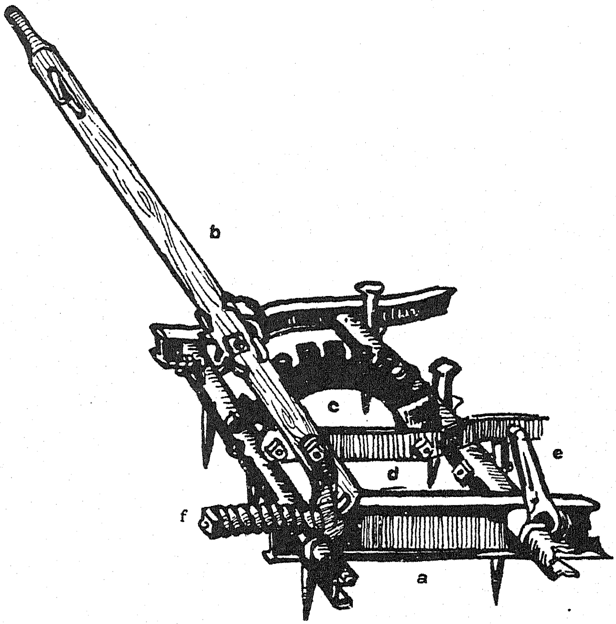


FIG. 46. Lever used for setting angle of the teeth.

bar (*d*). Each tooth bar carries a rocker arm (*e*) which is attached to the rocker bar.

The relief spring (*f*) permits the teeth to rock rearward when stones or other obstructions are struck, thus preventing breakage. After passing the obstruction the spring returns the teeth to their working position. The flexible pipe-bar harrow, shown in Fig. 47, is to a certain extent adjustable without the use of levers. This type may be drawn from either end. When

it is drawn from one end, the teeth stand in a vertical position and penetrate deeply. When it is drawn from the other end, the teeth slant backward slightly and cut lightly. The latter position is desirable for smoothing and light harrowing, or for

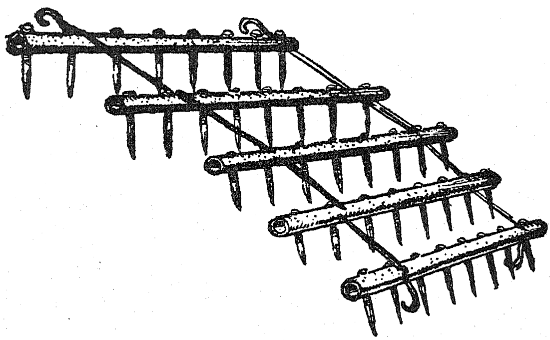


FIG. 47. Flexible pipe-bar harrow.

killing weeds after the crop is up. This type may be rolled up or folded for storage or transportation.

In the flexible harrow each tooth bar is hinged, or linked, to the next. This flexibility enables the harrow to fallow uneven ground and to work it better than the rigid type.

Draft Hooks. The draft hooks (Fig. 48*a*) are made of steel; one is placed at each front corner of every section. The harrow is drawn from these hooks. They must be so constructed that hitching is easy and quick, and yet the hitch must be secure when the harrow is in use. Some draft hooks have a self-locking device that helps to make a secure connection at this point. The lock may be easily pushed forward and the harrow section released

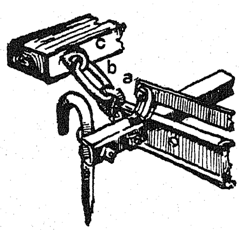


FIG. 48. Connection of harrow section to evener.

when this is desired. The *pig-tail* type of draft hook is shown

at *a*. This is twisted so that there is little chance of a section's becoming unhooked in the field, yet it may easily be disconnected when desired.

Draft Links (Fig. 48*b*). The draft links, which are made of steel, connect the eveners to the draft hooks. They are fastened to the eveners by means of the eye bolt (*c*).

Eveners (Fig. 49). The eveners for spike-tooth harrows are made of wood. They are connected to the front corners of

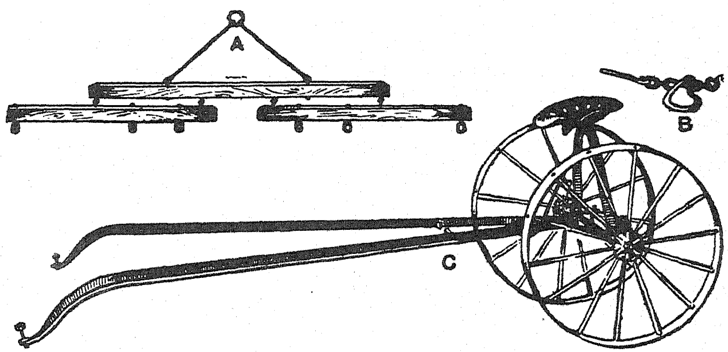


FIG. 49. Drawrods, hitch rings, and harrow cart.

all the harrow sections. If properly attached, they cause all the sections to pull straight and evenly. Each section is fastened to the evener independently of the others, and the sections are not fastened to each other. This provides great flexibility. One section may be raised to pass over a high place in the field or may drop down into a low place, without affecting the other sections. Combination eveners (Fig. 49*A*) are used for three sections and more.

Drawrods and Hitch Ring (Fig. 49*A*). These attach the harrow to the tractor or power that draws it. A clevis passes through the hitch ring. The drawrods must be attached to the evener so that the hitch ring will be ahead of the center of the harrow. The drawrods are necessary in order that the power may act along the whole length of the evener. It would

be difficult to make the harrow draw straight and evenly without the wide-spread drawrods. Some harrows have a hitch ring of the type shown at B in Fig. 49. This ring may be slipped a short distance in either direction along the chain links that connect the drawrods. In this way the position in which the harrows draw best can easily be found. This type is called a *grab ring.*

Attachments and Accessories

Harrow Cart. A harrow cart is very desirable for use with a horse-drawn, spike-tooth harrow. It permits the operator to ride. The long arms reach forward over the harrow sections and are attached to the eveners.

Three-Rocker Arm Attachment. Adding two rocker arms to the center one on open harrows may be desirable for working hard ground. A plank may be placed across these three arms so that the operator, in order to get better penetration, may ride and add his weight.

Trailer Hitch. With a trailer hitch, a harrow section may be drawn directly behind the plow. This not only means a saving of time but, in many cases, also provides a more adequate and economical load for the tractor.

Leveling Board. An adjustable leveling board completes the work of breaking lumps and pulverizing the soil, and levels it to a smooth, even surface ready for planting. The leveling board can be raised or lowered and set at any different angles, permitting very fine adjustment.

JOB 6

TO REPAIR A SPIKE-TOOTH HARROW

Procedure

1. Get owner's report on the condition of the harrow; field troubles; worn, broken, or missing parts; faulty adjustments; name of manufacturer and year of purchase, etc.

2. Test and inspect the harrow carefully. Disassemble and clean the various parts as required to make a thorough inspection for worn or broken parts.

3. Make a list of all repair operations needed.

4. Order repair parts. (See p. 51.)

A typical repair job on a spike-tooth harrow usually reouires the following operations.

Remove and Sharpen the Teeth

The front edge of the tooth must be sharp. If it is worn it may be possible to secure a new cutting edge by giving the tooth a one-quarter or one-half turn in the tooth clamp. If all the cutting edges are worn, the tooth must be removed and reshaped by hammering on the anvil. If the tooth has been worn down until it is so short that it cannot be set as deeply as the other teeth, it should be replaced with a new one. The points of the teeth wear the most, the tapered part wearing off and leaving a short, blunt point. Sharpening a tooth should restore the original shape. The tooth must be heated in the forge, care being taken not to heat it too much since this changes the temper of the steel and may weaken the tooth.

The teeth may be reshaped by grinding if a forge and anvil are not available.

Straighten the Tooth Bars If Necessary

A bent tooth bar is easily noticed. It must be removed and straightened by hammering on the anvil. It is not necessary to heat the tooth bar before hammering.

Tighten the Connection of the Tooth Bar to the Guard Rail

In some harrows the tooth bar passes through the guard rail. In others, a short extension is bolted or riveted to the tooth bar, this extension passing through the guard rail.

Adjust the Teeth

The teeth should be set in the clamps so that they will all penetrate equally. Space them correctly on the tooth bars. No tooth should trail another.

Tighten All the Tooth Clamps

Replace any broken ones. In some makes of harrows the tooth clamps may slip out of place along the tooth bars, thus changing the spacing of the teeth. See that the tooth clamps are set so that no tooth is directly behind another.

Replace the Drag Links If Necessary

Tighten the Eye Bolts

These connect the drag links to the evener. If the hole in the evener, through which these eye bolts pass, has become enlarged, a larger-sized eye bolt should be used. It is necessary that the bolt fill the hole completely; otherwise the bolt will jerk and churn when the harrow is in operation and will wear the hole larger.

Tighten the Bolts or Rivets in the Draft Hooks

Replace any that are broken.

Tighten the Bolts or Rivets in the Corner Braces

If these bolts or rivets are allowed to remain loose, the effectiveness of the corner brace is lost.

Repair the Runner Teeth

Sharpen the points, as explained in the first part of this job. If the curved part of a runner tooth is badly worn, replace it with a new one.

Test Action of Levers

The lever-latch handles, latch rods, quadrants, detents, rocker arms and all parts that affect the angling of the tooth bars should be tested and repaired as needed. Latch handles may need replacement, or the latch rods may need shortening in order that the lever detents may release properly.

Paint All Parts of the Harrow

Linseed oil, if desired, may be used, instead of paint on the eveners. Painting preserves the harrow, protects it from rust, and increases the years of useful service obtained from it.

Disk Harrows

The disk harrow is used for many purposes. The sharp, rolling disks penetrate well. It is an excellent implement for use on ground that has stalks, stubble, or vines, and it is often used on such ground before plowing. The disks cut up the surface trash so that it is all turned under by the plow. It is also very effective on sod ground and on fields where the soil

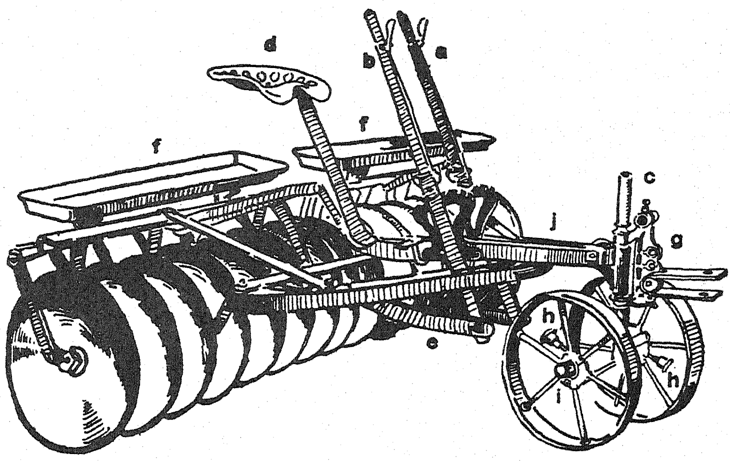


Fig. 50. Horse-drawn disk harrow with tongue truck.

is hard. If necessary, weights can be carried to secure deep penetration on hard ground. The action of the disk harrow is not hindered by trash as much as the spike-tooth harrow.

The disk harrow does not level mellow ground as well or pulverize it as finely as the spike-tooth harrow. It is, therefore, not classed as a smoothing harrow. For this reason, a spike-tooth harrow is often drawn behind the disk harrow. The disk cuts through the lumps, clods, and roots; the spike-tooth levels and smooths the ground. The combination makes an excellent seed bed.

Because of the deep penetration of this harrow, it is some-

times used instead of the plow. Under certain conditions it is satisfactory to seed in the crop after the ground has been disked, without the use of the plow. The disk harrow is also used for covering seed that has been broadcast, for cultivating orchards, and for mulching the upper surface of the soil to preserve moisture.

Types and Sizes. Horse-drawn disk harrows vary in width from 4 to 10 feet. The disks are usually spaced 6 inches apart. Thus an 8-foot harrow, which is a standard size, has 16 disks. The disks are 16 or 18 inches in diameter on horse-drawn harrows.

Tandem attachments may be secured for horse-drawn harrows. The disks of the front harrow throw the soil outward and those on the rear harrow throw it inward, thus working the ground twice for each trip across the field.

The front harrow is put into working position by moving the inner ends of the front disk gangs toward the rear; the rear harrow takes up its working position when the outer ends of the rear harrow move toward the rear. (See Fig. 58.)

The smaller horse-drawn harrows, 3 to 5 feet in width, may be obtained with reversible disk gangs. These gangs may be reversed or changed from one side of the harrow to the other, thus changing their action from inthrow to outthrow.

They are used for general seed bed preparation, for orchards, in vineyards, and for cultivating growing crops. With the disks set for inthrow, the harrow is used for ridging, making up beds for planting, and throwing up checks in irrigated fields. The disks are reversed when it is desirable to throw soil away from the row, or for shallow trenching. For seed bed tillage, the disk gangs are set close together at the center. For cultivating, they may be spread apart to permit straddling a row of plants, or spaced still wider for work in orchards or vineyards to permit disking close to the trunks of trees or roots of vines without injuring the branches.

Reversible tractor disk harrows, constructed in the manner

just described but heavier and wider, are now available. The disk gangs are easily changed from inthrow to outthrow and may be used in orchards or for general field work. They are usually single-action.

Tractor disk harrows are usually furnished with tandem attachment; they vary in width from 5 feet to 10 feet. The size

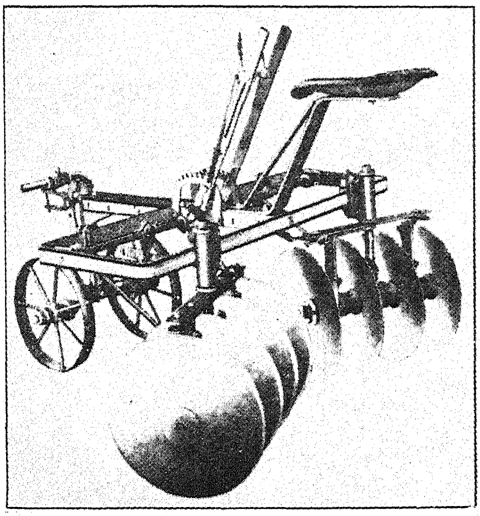


FIG. 51. Reversible disk harrow.

selected depends upon the power available. Disks of 16 inches, 18 inches, or 20 inches are supplied for ordinary tillage work, but heavy-duty tractor disks are available. These are used instead of the plow in orchards and for turning under cover crops, etc. The disks are 22 inches or 24 inches in diameter. Large disks with their greater curvature, or "dish," give better inversion and covering.

Special Types

The Bush or Bog Harrow. This is furnished with cutout disks. It cuts stalks effectively and penetrates well. Disks of

22-inch diameter, spaced 9 inches apart, are customary. Cutaway or cutout disks cut through stalks and surface growth better than plain disks; they have a better cutting or chopping action, but do not cover growth or pulverize as well as the plain disk.

Offset or Orchard Disks (Fig. 52). These disks permit the harrow to be offset so that it may travel to the right or the

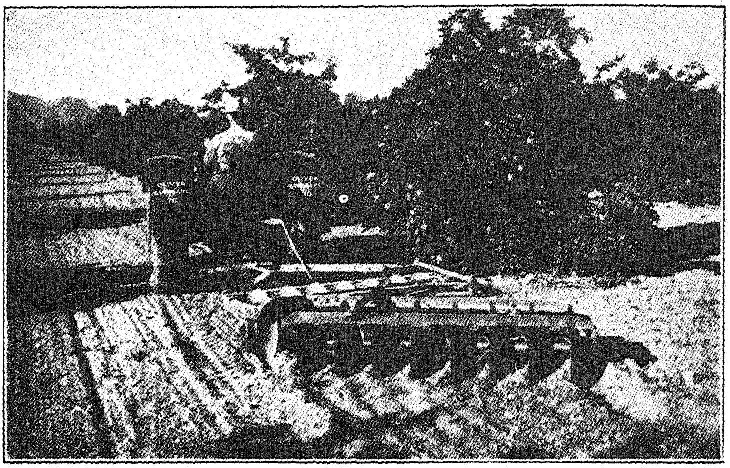


FIG. 52. Offset or orchard disk.

left of the tractor, thus working close to the trunks of trees beneath overhanging branches. The construction is such that no levers are needed for angling; no part of the harrow projects above the top of the disks; weight boxes are placed low and behind the disks. Disks 22 or more inches in diameter, with 9-inch spacing, are used.

Offset disks are used by many operators for general field work, with good results. They are constructed so that two straight rows of disks perform the work; whereas four rows, or gangs, of disks, with four distinct angles, are used in the conventional type. In the conventional type, ridging often

occurs at the center of the rear harrow. Ridging may be lessened by reducing the angle, but this gives less penetration and less work is accomplished by the rear harrow. With the offset type, the maximum angle may be used and still the ground may be left level.

Each front disk throws the soil about 9 inches to the right. The rear disk gang for general work is set 9 inches to the right of the front gang. Therefore, the rear disks catch the soil moved by the front and return it (9 inches) to the left. This action, although working the soil thoroughly and pulverizing and covering well, keeps the field level.

The cutting angle is automatically reduced when corners are turned, eliminating objectionable ridging at the ends of the fields or rows.

Wide Disk Harrow. Under the conditions listed below a single disking is sufficient or desirable and a wide, single-

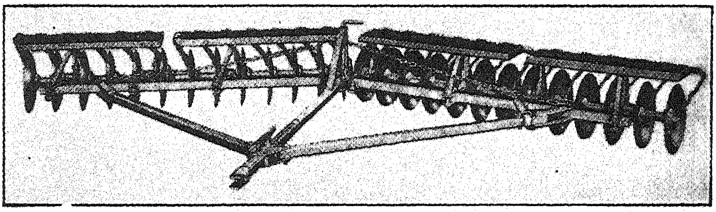


Fig. 53. Wide, tractor disk harrow.

action disk is preferable to the double-action. Time is saved and the work performed more economically by cutting a wide swath:

1. Whenever double disking is not necessary.
2. Where it may be desirable to disk the entire field in one direction and then crossdisk it.
3. For preparing wheat land.
4. For killing weeds and cultivating summer fallow, one single disking followed by another in a day or two may be more effective than a double disking.

Wide, single-action disks are made in widths of 12 to 21 feet. The outer gangs are hinged to the inner gangs and, for transport, they are folded over the inner gangs in an inverted position so that the harrows may pass through gates and lanes.

Construction and Principal Parts

The construction of all the various sizes and types of disk harrows is similar in many respects; differences in construction consist chiefly in the greater weight, larger disks, wider spacing, and heavier construction of the larger tractor disks, as compared with the light, horse-drawn sizes.

Disks. The disks are concave in shape, the amount of concavity usually being 2 to 4 inches. This is referred to as the *dish* of the disk. The dish of the disk increases the penetrating and pulverizing ability of the harrow as well as its ability to turn or invert the soil. Disks of maximum concavity, suitably weighted, cover surface growth well. The disks are made of high-grade, heat-treated steel. A long square bolt (Fig. 54*a*) passes through the square hole in the center of the disk. The head of this *arbor bolt* is large and square, and it is fitted with a washer conforming to the shape of the disk. The threaded end is also fitted with a washer and locking device. The disks are assembled on the arbor bolt, correctly spaced with the spacing spools and bearing spools, and then locked into a tight unit or gang by drawing up the large nut on the end of the arbor bolt. Disk, spools, and arbor revolve as a unit. Disks turn *with* the bolt, not *on* it.

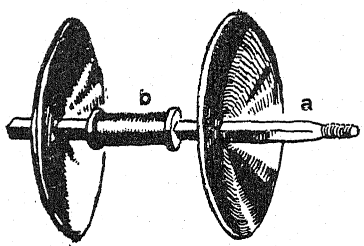


FIG. 54. Disks, arbor bolt, and spacing tool.

Main Frame. The main frame is usually made of single steel bars and is triangular in shape (Fig. 55). The rear of the

frame is attached to the bearings of the front disk gangs; the drawbar for the tractor disks, or the stub pole for horse-drawn models, passes through the center of the frame. The levers, or angling device for controlling the working angle of the gangs, are attached to the forward part of the frame.

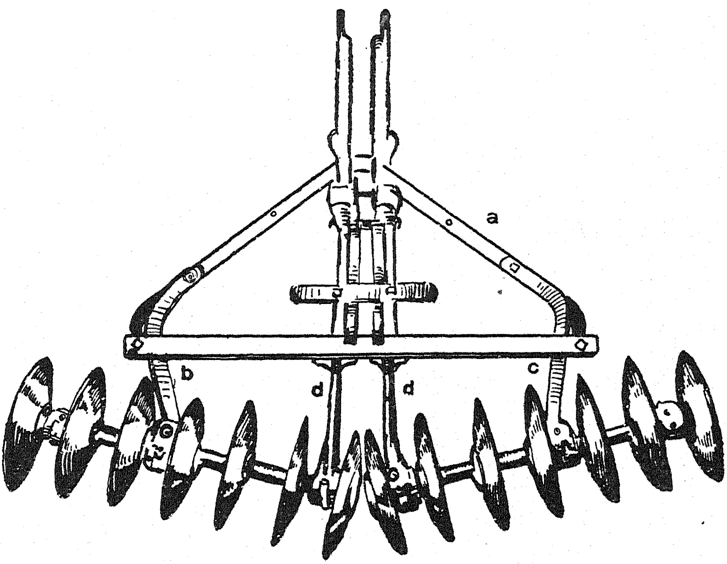


FIG. 55. Connection of main frame to disk gangs.

Draft Links. The steel draft links (Fig. 55*b* and *c*) connect the outer ends of the main frame to the disk gangs. The couplings which attach the draft links to the disk gangs are slotted so that the draft links pull in a direct line under all settings of the disk.

Set Lever Bars. The set lever bars (Fig. 55*d*) connect the inner ends of the disk gangs to the frame. These lever bars are set by means of the angling levers or angling device. When the lever bars are pulled forward as far as possible, the disks are all in a straight line. In this position they are transported to

and from the field. With the lever bars moved as far backward as possible, the disk gangs take up the greatest angle and the harrow penetrates most deeply. The harrow may be set at any angle between these two extremes, depending upon the type of work to be done. For light work, where deep penetration is not necessary, the angle of the disk gang is decreased.

Lever for Horse-drawn Disks

(*a*) *Angling Levers.* Manually operated levers are used for setting the angle of horse-drawn disks. Usually one lever is supplied for each disk gang. The levers are connected to the set lever bars.

(*b*) *Pressure Levers.* Some disk harrows are provided with a special pressure lever, often called a third lever. By means of the third lever, a downward pressure is placed on the lever bars. As these lever bars are attached to the inner ends of the disk gangs, this downward pressure causes the inside disks to penetrate more deeply. In field operation there is a tendency for the concave end of a disk gang to penetrate more deeply than the convex end. This is overcome by the adjustment of the third lever. Figure 60 shows how this same pressure adjustment is made without the lever. Here an adjustable snubbing block is used, the lever bars passing through slots in the block. Setting the block down puts more pressure on the inner disks and causes them to penetrate more deeply. The pressure on the inside disks should be regulated so that they all penetrate evenly. Pressure adjustments are discussed further on p. 94.

Bumpers (Fig. 56). When the harrow is in operation, the pressure of the soil tends to force the front gangs together at the center. To prevent the inside disks of the front gangs from rubbing against each other, large concave washers are used. These are called *bumpers*, and are shaped to fit the disk. The bumpers rub together and prevent the inside disks from touching each other. The head of the arbor bolt fits into the large square in the center of the bumper, as shown at *c*.

Well-designed bumpers prevent the disks from rubbing each other at any angle at which the disk gangs are set.

Spools. (Fig. 54*b*). The disks are spaced at definite intervals along the arbor bolt. They are held this distance apart by means of the spools. The arbor bolt passes through the

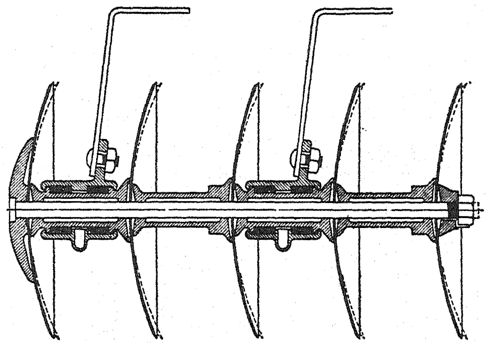


FIG. 56. Cross section of disk gang.

square hole in the center of the spools. The ends of the spools are shaped to fit the disk. When the nut on the end of the arbor bolt is drawn tight, the disks and spools draw tightly together and revolve as a single unit.

Bearings. Two or three of the spools on each gang are used for bearings as well as for spacing spools. The bearing surface of these spools is machined to a smooth finish. One or more heavy ribs or flanges are cast as an integral part of the spool. These exclude dust and grit and serve as a closure for retaining the lubricant. But an equally important function of the flanges is to carry the heavy end thrust that exists because of the angle at which the disks work.

On the front harrow the pressure is inward and much of the thrust load is carried by the bumpers or rubbing plates at the inner ends of the disk gangs. But on the rear harrow, the pressure is outward and all the side thrust must be carried by

the bearings. Hence, the thrust ribs, or flanges of the rear-bearing spools are large and heavy.

Several types of bearings are shown in Fig. 57. Some designs employ cast iron for the bearings and permit a metal-to-metal

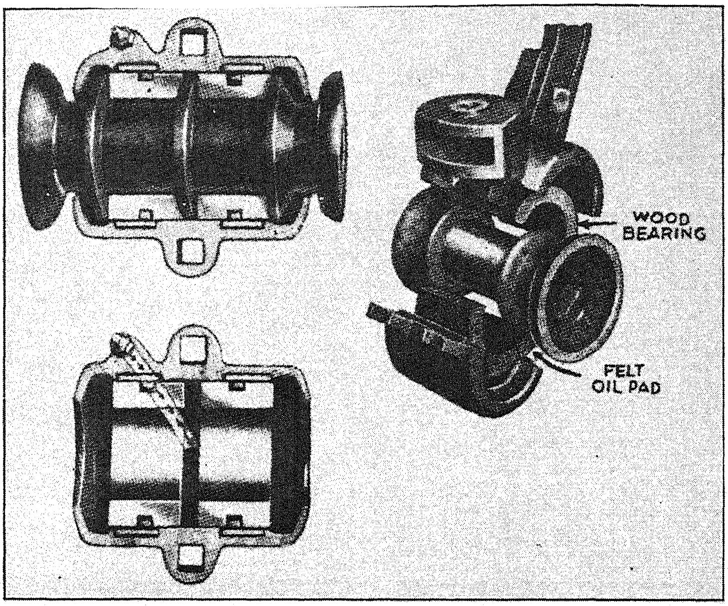


FIG. 57. Disk-harrow bearings.

contact. Other designs insert wood liners (oil-soaked maple) between the revolving spool and the stationary part of the bearing. Another construction employs a wood bushing in the upper half and an oil-soaked felt pad in the lower half of the bearing.

It is essential that the arbor bolts be kept tight, as this in turn enables the bearing to retain its lubricant and exclude dust. In sandy, gritty soils, however, it is extremely difficult to keep excluding such material. Frequent greasing, in sufficient quantity to force the old grease from the bearings, is desirable under such conditions.

Most bearings are supplied with pressure-type lubrication fittings and proper lubrication is not difficult.

To a limited extent, roller bearings have been used on disk harrows, but a tight bearing closure that would entirely exclude dust and grit—an essential to such bearings—adds considerably to the cost.

Weight Boxes (Fig. 50*f*). Sacks filled with sand, rocks, or other heavy material are used as weight. The weight boxes are bolted to the gang frames. The rectangular gang frame is itself suitable for carrying the weights.

Scraper Assembly. One scraper is provided for each disk, to keep the disk clean and prevent its becoming clogged up. The scrapers are particularly useful on wet, sticky fields. They are attached to a bar or connected directly to the gang frame.

On horse-drawn harrows, where the operator rides on the implement, a foot lever is connected to the scraper bar. By moving this, the operator causes the scrapers to move from the center to the outer edge of the disk, thus keeping the entire surface clean. The scrapers are returned toward the center of the disks by a coil spring on the scraper bar. The tension of this spring is usually adjustable.

The scrapers are made of steel and are easily replaced when worn or broken. They are usually adjustable and should be set so that they will just clear the disks when the harrow is in operation. A stop is provided for the foot lever so that the scrapers cannot be pushed off the outer edge of the disk.

Tractor disk harrows do not have levers for adjusting the scrapers because the operator does not ride on the harrow. The scrapers are set in a fixed position, which may be changed, however, if necessary. In general, the scrapers should be set about 1 inch from the outer edge of the disk. If they are set too close to the edge, they may be carried off. The end of the scraper should be set so that it clears the surface of the disk when the harrow is in operation.

Tongue Truck (Fig. 50). Horse-drawn disk harrows usually have a tongue truck to support the front end of the main

frame. This weight would otherwise be carried on the necks of the horses. Tractor disks are not equipped with tongue trucks as the weight is easily carried on the drawbar of the tractor and a tongue truck is not necessary. A draft iron and a vertical clevis (Fig. 50*g*) are provided to make the hitch adjustable. The wheels of the tongue truck should be well lubricated. The hub caps can serve as a grease cup, or special lubrication fittings may be provided.

Stub Pole (Fig. 50). Both horse-drawn and tractor disk harrows are furnished with a short or stub pole. This is usually built into the main frame. The tongue truck is connected to the underside of the stub pole, and the vertical clevis (*g*) is also bolted to it.

Tractor-harrow Angling Device. Some tractor disk harrows are angled by a manually operated lever or crank. Others

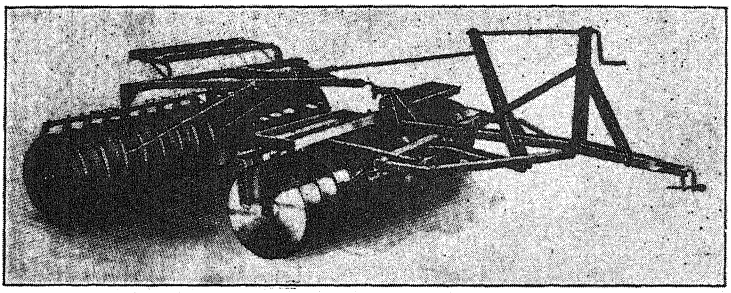


FIG. 58. Tractor disk harrow with manual angling device.

employ an automatic device, which makes it possible to angle the gangs with tractor power.

The principle of the manual method is illustrated in Fig. 58. When the adjusting crank is turned clockwise, the upper part of the angling lever is drawn forward. Then this forward motion is connected to the center of the two rear gangs and draws them forward to the working position.

The lower portion of the angling lever is forced backwards,

when the adjusting screw is turned clockwise. This forces the center of the rear gangs backwards into their working positions.

In the construction illustrated, the front gangs pivot in their outer bearings to permit the center of the front gangs to be forced backwards into working position; the rear gangs pivot in their outer bearings to permit the centers of the rear gangs to be drawn forward into working position.

An automatic angling device is usually provided on tractor disk harrows. When the trip rope or rod is pulled and the lock released, both the sliding drawbar and the gang adjustment move forward with the tractor. This forces the lower portion of set lever backwards, and the two set lever bars transmit this motion to the centers of the front disk gangs and force them into working position.

When the tractor is backed up, the sliding drawbar and gang adjuster slip backwards, the opposite action takes place, and the center of the front disk gangs are drawn forward into transport position.

The centers of the front disk gangs are connected by the inner drawbars and the rear harrow frame to the outer ends of the rear disk gangs. The centers of the rear gangs are connected to the outside ends of the front gangs.

When the centers of the front gangs move backwards to their working position, they also force backwards the outer ends of the rear disk gangs. The front gangs pivot at their outer bearings, and the rear gangs pivot at their center bearings to permit this change of angle.

It is frequently desirable to set the rear gangs at a different angle from the front gangs. Most manufacturers provide such an adjustment.

Attachments and Accessories

Transport Trucks. Where long trips to and from the fields over rocky ground are required, the use of transport trucks is desirable. They prevent excessive wear and dulling

of the disks. The transport trucks may be quickly put on or removed without the use of any tools. They protect the edges of the disks and prevent the cutting up of roads. One transport-truck wheel is necessary for each disk gang. A harrow with a tandem attachment, therefore, would require four transport-truck wheels.

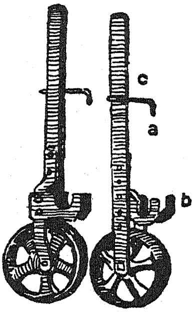


FIG. 59. Transport trucks for disk harrow.

Trailer Hitch. It is frequently possible and economical to use another implement in combination with the disk harrow. Spike-tooth harrows, soil pulverizers, seeders, and grain drills are examples of such a combination, but the trailed implement should be connected to a part of the harrow which can withstand the extra load. The custom of attaching the trailed implement to the scraper assembly or bearing standards of the rear harrow imposes an excessive strain on the rear harrow bearings and soon ruins them.

Rope-controlled Scrapers. In sticky soils, rope-controlled scrapers enable the operator to move the scrapers to any desired position on the disks while the harrow is in motion. This makes their action more effective.

Center Tooth. A narrow strip of ground is left at the center of a single-action disk harrow. This may be eliminated with the center-tooth attachment.

Hitch Stand. This attachment supports the drawbar and clevis at the proper height to facilitate connection to the tractor.

Frame Shields. The shields used in orchard work project backwards from the frame and cover the disks, lessening the damage to branches or vines.

Weights. Special weights for attachment above the disks may be secured. They also serve as shields in orchard work.

Depth Gauges. The use of two or more depth gauges on each gang makes it possible to limit the depth of penetration.

Seeding Attachments. Grain-seeding attachments are available, which drop the seed in rows on the surface of the ground so that the seed may be covered by the following disks.

JOB 7

TO REPAIR A DISK HARROW

Procedure

1. Get owner's report on the condition of the harrow; field troubles; worn, broken, or missing parts; faulty adjustments; name of manufacturer; and year of purchase.
2. Test and inspect the harrow carefully. Disassemble and clean the various parts to facilitate thorough inspection for worn or broken parts.
3. List all repair operations required.
4. Order repair parts.

If the disk harrow has been used for several years most of the following repair operations will be needed.

Clean and Repair the Bearings

To test the bearings, stand with the legs astraddle the disk gang. Grasp the gang frame directly above the bearing to be tested, and jerk the frame up and down. If the frame moves without lifting the disk gang, the bearing is worn. Remove the grease fitting and take out the bolts which hold the halves of the bearing together. Disconnect the draft links and lever bars from the bearings. Pull the halves of the bearings apart. Take out the old bushings and wash the grease and dirt off the bearing spool and the halves of the bearing. Fit in new bushings, seeing that they fit down into their place properly. Clean the grease tube and test it to see that grease is forced through the tube easily. These parts should not be put back in place until after the disks have been removed and sharpened.

The wood bushings provided for some harrows have been treated with oil and graphite during the manufacturing process and require no further lubrication. But all wood bushings should be replaced before the amount of wear has become so great that the metal-bearing standard bears against the metal-bearing spool. Wear should take place on the wood, not on the metal.

Test all the disk bearings in the same manner, and replace the bushings wherever necessary.

Sharpen the Disks

To do this, it is desirable to take the disks off the arbor bolt. Take off the nut on the end of the arbor bolt, and remove the first disk. Then remove the first disk spool and the second disk. It is well to lay the disk spools aside in the order in which they are taken off, as the bearing spools are different from the others and must be put back in their proper places. The disks are sharpened by grinding. They are of highly tempered steel and must not be ground too fast or else the heat set up will change their temper. They are ground to a cutting edge on the back or convex side. The edge should not be made too thin, for a too-thin edge will cause it to chip out easily. It is well to finish grinding all of the disks of one gang and then reassemble them before starting another gang. In this way, fewer parts are left lying about and there is less confusion.

Disk-sharpening attachments, which function while the harrow is in use, are available. The need for sharp disks is greater if sod ground, stubble, surface growth, and cover crops are to be worked with the harrow. On sandy and gravelly soils, sharpening the disks may be undesirable as the thin, sharpened edge will wear rapidly.

Examine the Arbor Bolt

If, as often happens, the arbor bolt has become bent, it may be straightened by hammering it on the anvil. It is not necessary to heat it.

Reassemble the Disks on the Arbor Bolt

Space them properly with the disk spools. Be sure that the bearing spools are in the correct position on the disk gang; this is between the disks where the draft links and lever bars are to be connected. Put the locking device or washer on the end of the arbor bolt, and tighten the nut well. Test the gang to see if it is completely tight. To do this, turn any one disk. It should cause all the other disks to turn with it. The whole gang should turn as a unit. If one disk can be turned even slightly without moving the others, it means that the arbor bolt is too loose. Complete all the work on one disk gang before disassembling another.

Examine the Gang Frame

Tighten the bolts or rivets that connect it to the bearing standard. Put in new bolts or rivets, if necessary, large enough to fill the holes snugly.

Replace Scrapers As Necessary

Adjust all the scrapers so that they just clear the surface of the disk when they are in the working position (about 1 inch from the outer edge of the disk). In most harrows the scrapers may be adjusted where the scraper bar connects to the gang frame, or each scraper may be adjusted separately where it is attached to the scraper bar. Examine the foot lever (if any), and adjust the foot-lever stop so that the scrapers cannot be pushed off the outside edge of the disk. Tighten the bolts or rivets that connect the stub pole (or drawbar) to the frame.

Examine the Levers

Oil the lever latches to prevent rust. See that these parts act freely. Test the angling levers or angling device. Examine the lever bars and straighten them if they are bent out of shape. Tighten the bolts that connect the snubbing blocks, or pressure rollers, to the main frame. (See Fig. 60.)

Repair the Weight Boxes

Usually they require straightening. The bolts attaching the weight boxes to the frame should be made tight.

Repair the Tongue Truck (on Horse-drawn Disks)

Jack up the front end of the stub pole to take the weight off the tongue truck. Rock the wheel on the axle to determine the amount of wear at this point. Remove the wheel and examine the axle and the inside of the wheel box or hub. Either the axle or the hub may be worn. The wheel hub is usually removable, and a new hub may be put in or a new axle used if necessary. Grease the axles well and replace the wheels.

Paint All Parts, Except the Disks

Often the painting may be done to best advantage while you are awaiting repair parts. Then the work is disassembled and the parts are readily accessible. The disks should not be painted, but cleaned and coated with varnish or grease, to prevent rust.

Operating a Disk Harrow

Lubrication. Most harrows require frequent and thorough lubrication. The bearings work under the most severe conditions, constantly in dust and grit, and subject to heavy thrust and radial loads or a combination of side pressure and vertical pressure. The bearing closures depend upon the lubricant itself to seal them against dust and grit. In other words, grease not only lubricates the bearing but also forces out dust and dirt.

Some types of bearings however are so designed that frequent lubrication is not recommended. Specially treated wooden bushings, or oil-soaked felts such as shown in Fig. 57, act as a reservoir for the lubricant.

The problem of lubricating farm machines has been simplified by the use of high-compression grease guns. With this equipment, it is easier to force grease into bearings. The use of such a system requires that the machines be equipped with special fittings. Most farm machines are now provided with this high-pressure lubricating equipment. Fittings remain permanently in their respective places.

Transportation. Usually the harrow is drawn to and from the field by rolling it on the disks, which are then set in a

straight line with no angle. Under some conditions, transport trucks may be required. To attach transport trucks (Fig. 59), push the end (*c*), with hook (*a*) attached, under the gang from the rear so that the saddle (*b*) rests beneath the bearing spool. Then lift the end (*c*) and hook it over the frame bar. One truck is required for each gang. If trucks are not required the harrow is transported by rolling on the disks, which are then set straight (no angle).

Hitch Adjustment. On standard types the center of the power can usually be connected to the center of resistance. A correct horizontal hitch, which permits the harrow to trail directly behind the tractor, is easily obtained.

The orchard harrow (Fig. 52) may be offset to the left by adjusting the drawbar to the left of the harrow, or to the right by setting the harrow drawbar toward the right.

In addition, if right turns are to be made, it is necessary to regulate the length of the chain. This chain trips the angling device automatically when making right turns, bringing the gangs to their straight or transport position during the turn. When the turn is completed the gangs again take their working angle.

The vertical hitch may be adjusted at the harrow drawbar or, if not adjusted here, it may be possible to adjust the tractor drawbar. The line of hitch should be slightly upward from the harrow to the tractor. Such a hitch means lighter draft and will tend to prevent the front disk gangs from penetrating too deeply on freshly plowed ground.

Penetration. Several factors determine the depth oɪ penetration. Chief among these, and the one most easily regulated, is the angle at which the disk gangs are operated. Maximum angle gives the deepest penetration; levers or a mechanical angling device make possible a variety of settings to adapt the angle to the field conditions present.

The sharpness of the disks, their diameter and concavity (dish) also affect penetration. Large disks, with concavity of 3 to 4 inches, often replace the plow in turning under green

manure crops. The additional weight and the wide spacing between disks on large harrows increase their penetration.

Weight boxes are provided, or may be obtained, for carrying the additional weight needed for hard ground.

Increasing the speed of travel tends to lessen penetration, but it may improve covering and pulverizing.

Cutaway disks penetrate well.

Pulverizing and Covering. The pulverizing action is determined by the working angle and the rate of travel, the concavity of the disks, the weight of harrow, the adjustment of the disk scrapers, and, most important, the condition of the soil.

Plain disks pulverize and level the soil better than cutout disks; but the cutout disks chop up surface growth well and distribute it through the seed bed.

Leveling the Disk Gangs. The inner ends or center of the front disk gangs tend to lift or raise out of the ground when the harrow is in action. The same tendency applies at the outer ends of the rear disk gangs. This is due to the thrust load set up on the gangs from the angle at which they work. With standard four-gang tractor disk harrows the concave end of each disk gang tends to cut more deeply than the convex end. Therefore, some means is desirable for leveling each gang, by adding pressure to the convex end of the gang. One such device employing adjustable pressure rollers is shown in Fig. 60. This serves to regulate the pressure at the center of the front disk gangs. A similar pressure roller placed at the center of each rear gang may be raised or lowered as required to keep each rear gang level.

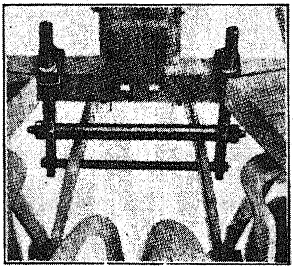


FIG. 60. Adjustable pressure rollers.

Rear-harrow Adjustments. The rear harrow may require a greater or lesser angle than the front harrow. To fill a dead

furrow, use a minimum angle on front and a maximum angle on the rear harrow; to cut down a back furrow, set the front harrow at maximum angle and the rear at minimum angle.

On some tractor harrows provision is made for changing slightly the spacing between the gangs of the rear harrow. This permits setting the rear disks so that they will split the ridges left by the disks of the front harrow.

Scrapers. On tractor harrows the scrapers should be set about 1 inch from the outer edge of the disk so that the scraper blade just clears the face of the disk when the harrow is in action. On horse-drawn harrows the foot lever should be adjusted so that the scraper may be moved freely from the center of the disk toward the outer edge, with the lever stop set to prevent the scraper from passing beyond the outer edge of the disk. Scraper blades should be set with their front point almost touching the disk, and the rear point of the blade ¼ inch clear of the disk. This setting lessens the chance that trash can be caught and retained on the scraper.

Arbor Bolt. Check the arbor bolt frequently and tighten it whenever necessary. It should never be possible to move one disk of a gang without the others. If it can be thus moved, the arbor bolt nut needs tightening. To let it remain loose will mean rapid wear and rounding of the square holes in the disks. The square arbor bolt also wears round; then it becomes almost impossible to lock the disk into a solid gang.

Spring-tooth Harrows

The spring-tooth harrow is especially useful for hard or stony ground. The strong steel teeth are not damaged or broken by striking obstructions. They pulverize the ground fairly well and can be set to penetrate deeply.

Another important use of the spring-tooth harrow is for destroying noxious grasses or weeds that are propagated by roots. The deeply penetrating teeth tear out the roots and bring them to the surface where the sunlight destroys them.

Cultivating alfalfa is also done advantageously with the special teeth provided for this purpose (Fig. 61).

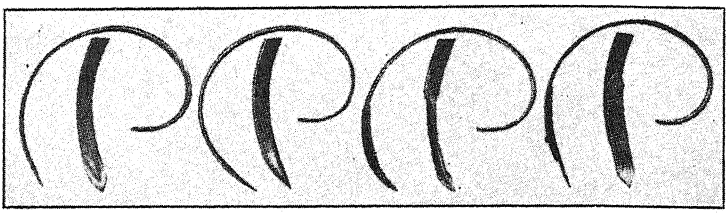


FIG. 61. Types of spring teeth—regular, quack-destroyer, alfalfa, and reversible-point.

Sizes. The spring-tooth harrow is made in sections as is the spike-tooth harrow. Each section of a horse-drawn harrow usually contains eight teeth and cuts a width of about 2½ feet. The number of sections used can easily be changed to suit the power available. As the sections are hinged together at the center, they pull evenly, yet each one follows the contour of the ground.

Tractor-harrow sections are about 5 feet in width, with approximately ten teeth per section. The semicircular spring teeth tend to rake up and retain trash which finally forces the harrow out of the ground.

Certain designs enable the operator, without leaving the seat of the tractor, to remove trash from the teeth. One such design is shown in Fig. 68. When the rope attached to the rear trip lever is pulled, the teeth roll one-half revolution forward and come to rest in the transport position. This action clears them of trash. While the harrow is in the transport position, its weight is carried on skids or runners, not on the backs of the teeth. When the trip rope is again used, the teeth roll forward another half revolution to their working position.

Construction

Teeth. The teeth are made of spring steel. They are long and are bent into an almost complete circle. The ends are sharpened and are usually from 1 to 1½ inches in width.

Some spring-tooth harrows are furnished with double-pointed teeth. These points are removable, and can be reversed so that a double-wearing surface is obtained.

In the standard section with eight teeth, the teeth are placed between 3 and 4 inches apart and do not trail each other. Because of the width of the teeth, this spacing harrows the ground very completely.

Tooth Bars. The tooth bars, which carry the teeth, are made in several different shapes. A round tooth bar and a channel tooth bar are shown in Fig. 62. Flat steel bars and square wooden tooth bars are also used. The tooth bars on the spring-tooth harrow are shorter than those on the spike-tooth harrow. The spring teeth penetrate deeply, and, as the

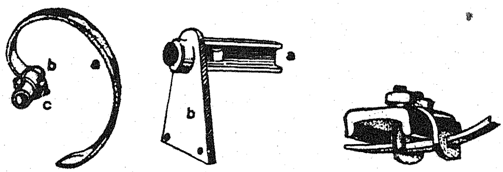


FIG. 62. Tooth bars.

harrow is frequently used on rough or hard ground, the tooth bars must be strong and well supported at the ends.

Tooth-bar Standards. The tooth-bar standards support the ends of the tooth bars. They are usually riveted to the frame. The ends of the tooth bars pivot in the tooth-bar standards to provide for setting the depth to which the teeth are to penetrate. The ends of the tooth bars pass through the standards and also act as cross braces to hold the frame together.

Tooth Clamps. The tooth clamps attach the teeth to the tooth bar. They prevent the tooth from moving sideways on the tooth bar, and yet permit depth adjustment of the tooth.

U-bolts and retainers are used to eliminate the need for bolt holes in the tooth.

Frame. An angle type of section frame is shown at *B*, Fig. 63. This is a single piece of angle steel, bent to enclose the front and both sides of the section. The frame must be strongly constructed since all strains are transmitted to it. Replaceable runner shoes are used beneath the frame. These make the actual contact with the ground and lessen the wear on the frame. They may be easily and cheaply replaced. The harrow is drawn directly from the frame.

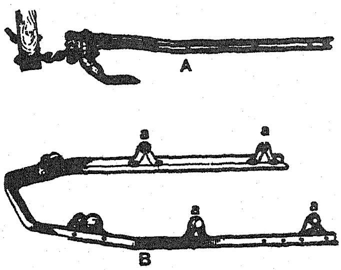


FIG. 63. Spring-tooth-harrow frame.

In some harrows the sides of the frame carry a runner beneath them (*A*). This runner, or shoe, is detachable and can be renewed when worn. The runners protect the frame and carry the weight of the harrow when it is being transported to or from the fields. Three runners are provided for each section, one in front and two at the rear corners. The frame is the base of the entire implement, and to it all parts are connected.

Levers (Fig. 64). The levers provide for setting the depth to which the teeth penetrate. Horse-drawn harrows have one lever for each section. This is also quite common for tractor harrows, although some are made so that with one lever all sections may be adjusted. Figure 65 shows a tractor harrow of this type. The movement of the levers causes the tooth bars to turn in the tooth-bar standards. The levers are connected to the tooth bars by the rocker bars (Fig. 66*a*) and the rocker arms (*b*). The levers and lever ratchets (*c*) are connected to the frame.

Clevis (Fig. 64). Several holes are usually provided so that the point of hitch may be raised or lowered, as required,

to secure the best results in the field. The clevis is riveted or bolted to the frame. Each section has one clevis.

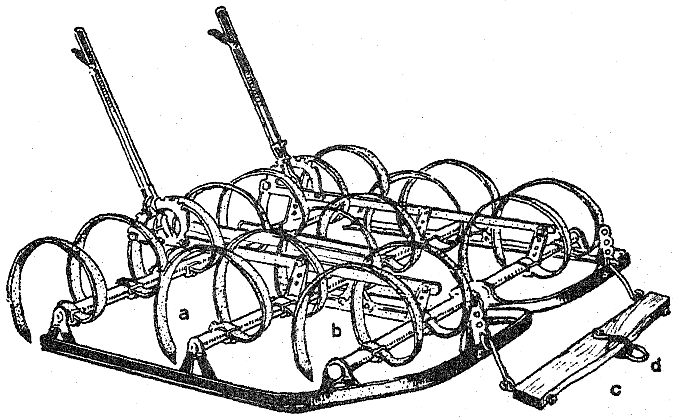


FIG. 64. Two-section spring-tooth harrow.

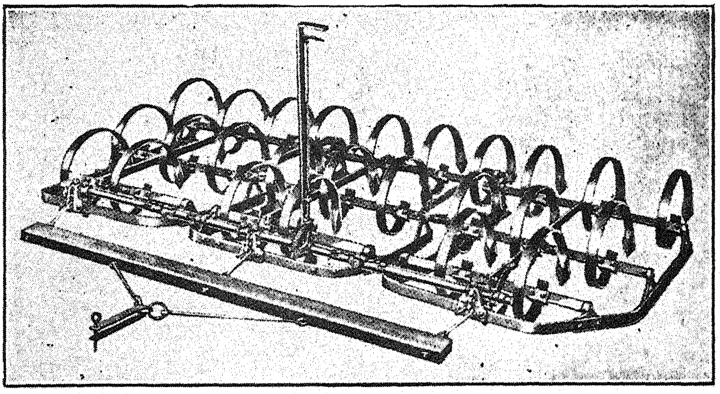


FIG. 65. Three-section spring-tooth tractor harrow.

Draft Links (Fig. 64). The draft links, which connect the eveners to the clevises, are so shaped that they can be quickly unhooked when desired and yet remain secure when the harrow is at work. An eye bolt connects the front end of the draft link to the evener.

Eveners. The evener, by which the draft is distributed evenly to all the sections, is made of wood. Various lengths

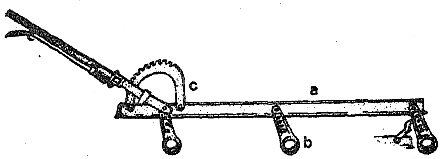


FIG. 66. Lever connections.

and combinations of eveners are furnished, according to the number of sections used.

Drawrods and Hitch Ring (Fig. 67). On two-section harrows the hitch is made by means of a clevis and ring, as shown at *d* in Fig. 64. Where more sections are used, drawrods and a hitch ring are necessary. By this means the power is attached to the evener at two points, thus causing the sections

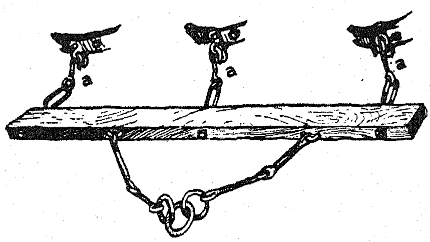


FIG. 67. Drawrods and hitch ring with three-section evener.

to pull evenly. The point of hitch (where power is attached) must be such that it will not allow the harrow to skew (one end to lag behind the other). On the two-section harrow it will be noted that the point of hitch falls directly ahead of the center of the two sections. On a three-section harrow the draw rods are attached to the evener in two places, as shown in Fig. 67.

Wheels. Wheels are furnished with spring-tooth harrows, if desired. The front wheels are attached to the center of the

section frame. Front wheels, of the caster type, are used in order that the harrow may turn more easily. The back wheels are mounted at the corners of the section on the rear tooth bar. A bushing is provided between the tooth bar and the wheel, and the wheel bears on this bushing instead of on the tooth bar. Provision is made for lubrication of this bearing. Horse-drawn harrows equipped with wheels can also be furnished with a seat for the operator.

JOB 8

TO REPAIR A SPRING-TOOTH HARROW

Procedure

Get owner's report on the condition of the harrow; field troubles; worn, broken, or missing parts; faulty adjustments; name of manufacturer; and year of purchase.

Test and inspect all parts carefully, noting each worn or broken part.

List all repair operations required.

Order the repair parts needed.

NOTE. Spring-tooth harrows are used principally on hard and stony ground. They penetrate deeply and do excellent work under severe conditions. It is well for the operator to keep this in mind and to give these harrows proper care and attention.

Sharpen or Replace Worn Teeth

The teeth should be sharp in order that the harrow may penetrate hard soil. The points wear round and may be reshaped by grinding on the back side. The cutting edge, or bevel, should be ground to an abrupt, tapered edge. A thin edge will not have the strength necessary to stand the severe usage to which the implement is subjected. The operator should notice the manner in which the teeth are ground when new, and should grind the worn teeth in the same manner. This is an excellent rule to follow in sharpening any edged tool. Grinding consists in restoring the edge as nearly as possible to its original shape.

If the teeth are badly worn, it may be desirable to restore their original shape by forging. Heat only as much of the steel as required to restore the pointed shape, and do not overheat it; work it at a dull cherry-red heat. When shape is restored, temper the point by allowing the steel to cool on the floor. Do not quench it in water.

Detachable points may be secured which can be clipped over the worn teeth; thus new points can be provided. These points are double-end or reversible.

Adjust and Space the Teeth

All the teeth should be set to the same depth. To do this, place the harrow on level ground or on a floor. Pull the lever back until the teeth touch the ground. Then examine all the teeth. If any do not touch they may be set deeper by adjustment at the tooth clamp.

Test all tooth clamps to determine whether any are loose or broken. Space them along the tooth bars so that each tooth will have its correct position in the harrow section. No tooth should trail another.

Repair the Frame and Frame Shoes

The frame is subjected to heavy strain. All other parts of the harrow are connected to it or are carried by it. Examine the frame bars of every section to see if any are bent or twisted. Tighten all bolts or rivets that connect the draft hooks, runner shoes, and tooth-bar standards to the frame. If the bolts and rivets in such connections remain loose, the holes through the frame become enlarged, making it difficult to secure a tight connection. In this case larger bolts or rivets should be used, the hole being drilled out a little larger, if necessary, to make the use of larger bolts or rivets possible.

The frame shoes beneath each side of the section frames should be examined and replaced if necessary. These shoes are inexpensive and replaced in time, will prevent the wear of more costly parts, and greatly lengthen the service from the implement.

Straighten the Tooth Bars and Rocker Bars

Examine all the tooth bars carefully to see if any are bent. Bent tooth bars will throw the teeth out of adjustment. They should be removed and straightened. This may be done by hammering them on the anvil. It is not necessary to heat them.

Straighten the rocker arms and rocker bars (Fig. 66*a* and *b*) and tighten the connections between them.

Test and Repair Levers

Test the action of the levers. Tighten the lever quadrants. Often the lever detents or plungers, which engage with the quadrant, become stuck in their guides, or their springs lose their tension and need to be stretched or replaced. The long rod connecting the latch handle to the plunger becomes stretched or bent so that the detent cannot be easily released from the quadrant.

Repair the Evener and Clevises

Tighten the bolts or rivets which attach the draft clevises to the frame, using, if necessary, new bolts or rivets large enough to fill the holes completely through all connecting parts. Inspect the draft links (Fig. 64) and the eye bolts which connect them to the evener, and replace them if necessary. The evener should be checked carefully for cracks or splits. If made of wood, it may be repainted with linseed oil. The drawrods and hitch ring may show sufficient wear to warrant their replacement or, if a welding outfit is available, the worn spots may be rebuilt with new metal.

Paint All Parts of the Harrow

Operating a Spring-tooth Harrow

Hitch Adjustment. The vertical hitch should be adjusted at the draft clevises (Fig. 64) to give an upward line of pull from the harrow to the power. With a correct hitch the harrow section will work in a level position with front and rear penetrating equally.

Clearing the Teeth of Trash. Their shape causes spring teeth to rake up and accumulate surface trash. The teeth can be cleared by the hand levers which raise them or, on tractor-

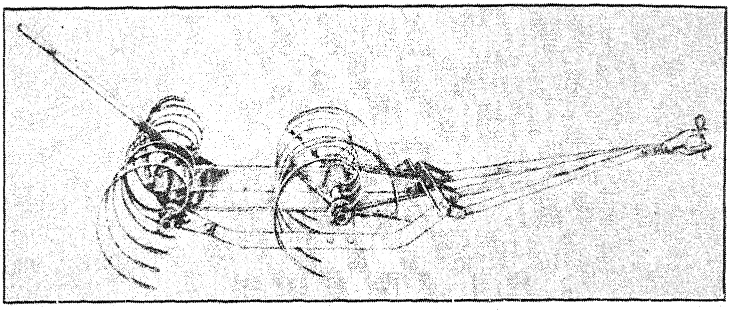


FIG. 68. "Rollover" tractor harrow.

controlled harrows, by the use of the automatic mechanism described on p. 96.

Special Equipment and Attachments (Fig. 69). The expanding attachment may be used to spread the two sections

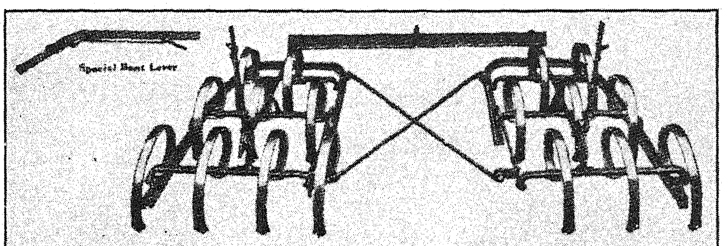


FIG. 69. Expanding attachment.

of horse-drawn harrows and to adapt them for work in orchards. The adjustment levers are also bent downward to prevent their catching on low branches.

The trailing teeth make a combination harrow that improves pulverizing and, to some extent, combines the smoothing effect

of a spike-tooth harrow with the penetrating ability of the spring teeth.

Gauge shoes may be needed under conditions where it is necessary accurately to limit and regulate the degree of penetration.

Special teeth may be needed for certain field jobs. Plain or regular teeth are used for general field work and pulverize the best. The narrow, sharp point of the quack grass tooth tears out roots and brings them to the surface so that they may be destroyed. The reversible or double-pointed tooth is best for use on stony ground. It may also be used as a replacement part, to be clamped over worn and rounded tooth points of the plain type.

Wide sweeps or surface-working shovels are efficient for killing weeds, and the winged furrowers give the ridging desired in irrigation work or in the control of soil blowing.

Lever Placement. Some horse-drawn harrows may be easily adapted for use with a tractor. The levers may be shifted from the rear to the front of the section and thus be accessible from the tractor seat.

Special Types

A curved-knife or coulter harrow is shown in Fig. 70. This harrow is also constructed in sections and can be procured in widths ranging from 3 feet to 28 feet. The smallest size is a one-section harrow and is suitable for use with one horse. The largest size is designed for tractor use.

The knives or coulters are spaced about 6 inches apart. The forward or flat knife part of the coulter or knife compacts the soil and crushes clods. The central part of the coulter has a narrow fin, extending downward, which causes deeper penetration. The bend or twist of the coulter blade works the soil both right and left. Between each coulter a short, flat bar called the *crushing spur* is used to aid in compacting the soil and crushing clods. Extra weight may be carried on the seat braces

when deep penetration is required. This type of harrow, when used under suitable conditions, leaves a finely pulverized and well-compacted seed bed.

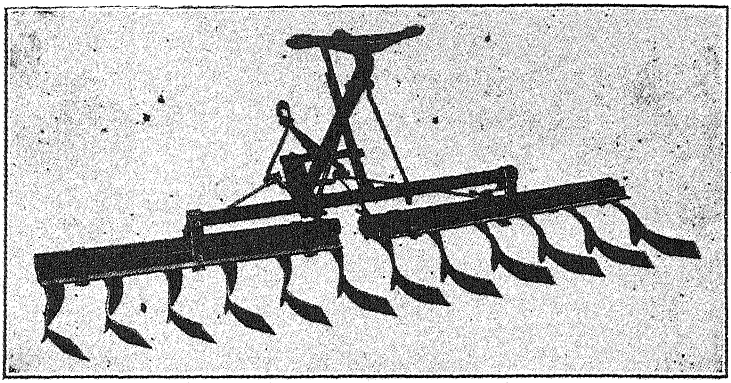


FIG. 70. Curved-knife or coulter harrow.

Figure 71 shows a type of smoothing harrow well adapted to the preparation of the seed bed for garden or truck crops, or wherever a very fine and smooth seed bed is required.

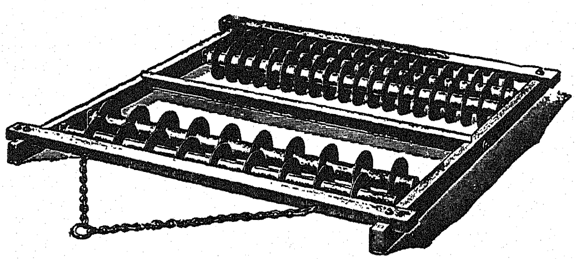


FIG. 71. Special type of smoothing harrow.

Four rows of small disks (8 or 10 inches in diameter), so placed that no one disk trails another, are used in this type of harrow. This distribution gives the soil a thorough working. The center board is set at an angle. It is adjustable up or

down and acts as a leveler, filling in the hollows and cutting down the ridges in the field.

This harrow may be secured in sizes suitable for one, two, three, or four horses. The width of the largest size is $8\frac{1}{2}$ feet. It is also designed for use with a tractor.

Selection of the Proper Type of Harrow

The various types of harrows and the conditions for which each type is suited were discussed at the outset of this chapter. Field conditions and the nature of the work will determine which type should be used, as each is distinctly adapted to certain conditions. Most extensive farming operations require the use of more than one type of harrow.

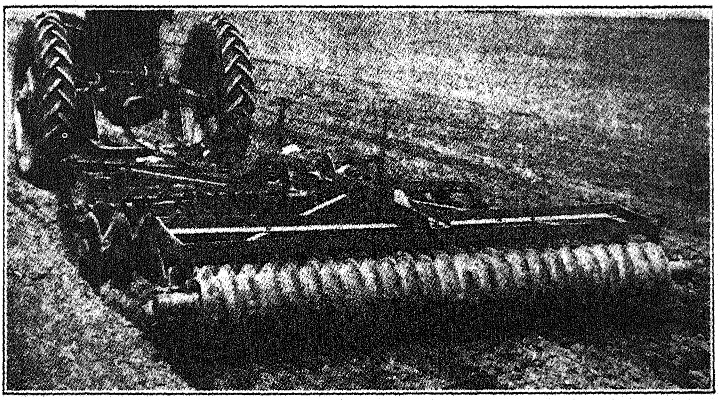


Fig. 72. Pulverizing roller.

The spike-tooth is the lightest in draft, and the disk is the heaviest. Leveling and smoothing are satisfactorily accomplished with the spike-tooth harrow. Hard, stony ground is advantageously worked with the spring-tooth harrow. The disk harrow is particularly serviceable on soddy or trashy ground, as the sharp, rolling disks can be set to cut well through the surface trash and penetrate deeply. The disk is, indeed, a

general-purpose implement and is widely used in seed bed preparation.

ROLLERS AND PULVERIZERS

Under certain conditions the use of heavy, cylindrical rollers improves the seed bed. They firm the soil, crush clods, reduce the air spaces, and press the topsoil and subsoil into firmer contact.

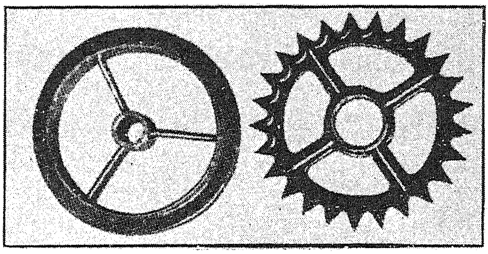


FIG. 73. Packer wheel and sprocket.

Smooth rollers are usually employed for meadow and grass lands, especially in the spring, when their action presses back into the soil the root masses that have been loosened by frost.

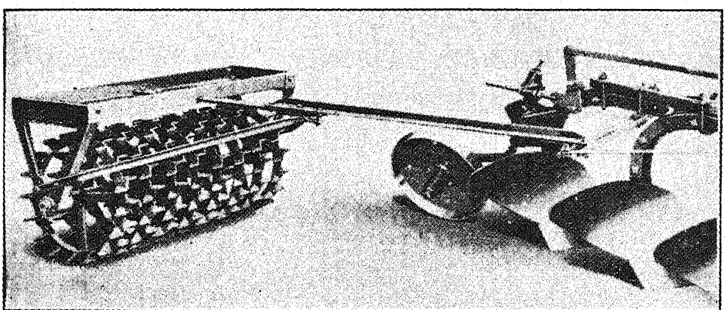


FIG. 74. Land packer and plow.

Pulverizing rollers with packer wheels, shaped as shown in Fig. 72, are used for seed bed preparation as well as immedi-

ately after seeding. The front packer wheels are usually 15 or 18 inches in diameter and $3\frac{1}{2}$ inches wide. The rear packer wheels are smaller (12 inches) and spaced to split the ridges formed by the front wheels.

The sprocket-type pulverizer (Fig. 73) is furnished with a loose sprocket or spike-tooth wheel adjacent to each packer wheel. These loose sprockets prevent clogging in wet, sticky soils and leave the surface in a mulched condition.

The mulcher wheel is assembled loosely on the main axle; it forces sticky soil from the packer wheel.

The land packer shown in Fig. 74 is designed to penetrate deeply and to pack the subsoil rather than the surface soil. It is frequently used in combination with the moldboard plow.

CHAPTER III

GRAIN-SEEDING MACHINES

There are two distinct classes of grain-seeding machines—broadcast seeders and drills. The former merely spread the seed over the surface of the ground; the latter deposit the seed in shallow furrows or trenches and cover it with soil. In some sections, especially where fields are small, grain is broadcast by hand. But small, inexpensive broadcasting machines are also available.

Broadcast Seeders

The *knapsack seeder* is carried with the shoulder strap. The seed is scattered by the vanes of the distributor wheel. A high gear ratio between the wheel and the hand crank causes the distributor wheel to revolve quickly and spread heavy seeds such as wheat or rye over a swath of 30 or more feet.

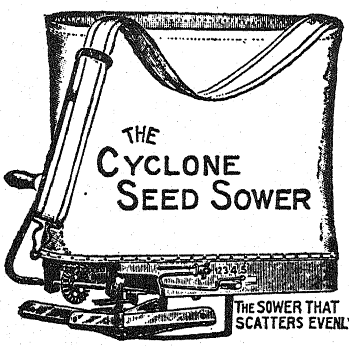


FIG. 75. Knapsack hand seeder.

The *wheelbarrow seeder* is used primarily for grass seed, alfalfa, clover, timothy, millet and similar seeds, although some models are adapted for sowing grain or commercial fertilizer. The length of the hopper is 10 to 16 feet. The 10-foot hopper holds 1½ bushels and weighs about 60 pounds. It may also be used for broadcasting. An agitator rope or chain, in the bottom of the hopper is oscillated over the seed outlets, with power taken from the single wheel. The movement or

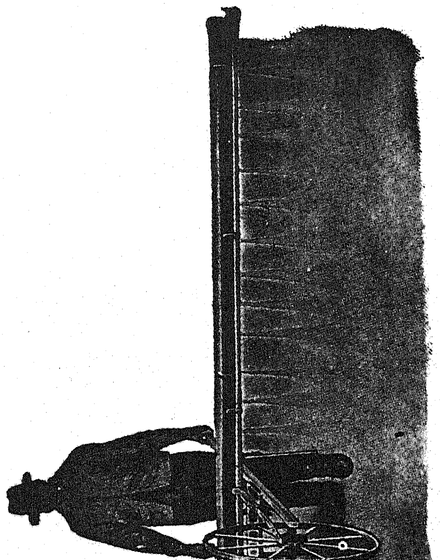


FIG. 76. Wheelbarrow seeder.

stroke of the agitating rope is adjusted to obtain the particular seeding rate desired. The hopper is usually provided with two rows of seed outlets. One row has round openings for sowing round seeds such as clover, alfalfa, and timothy, and the other has oblong openings for the light, chaffy, and bulky grass seeds such as orchard grass, bluegrass, redtop, etc.

The *end-gate seeder* is attached to the end gate of a wagon, and seed is shoveled into it from the wagon box. The dis-

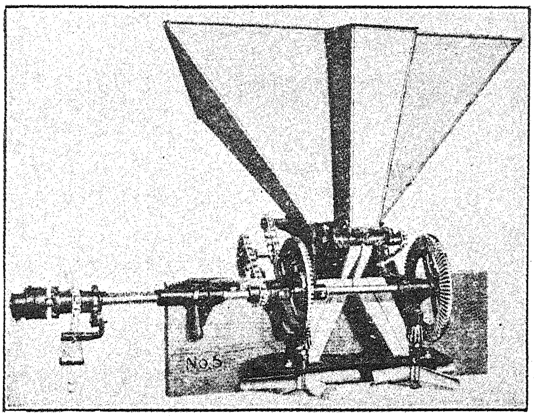


FIG. 77. End-gate seeder.

tributor wheels are driven by a chain from a sprocket attached to one of the wagon wheels. These vaned distributor wheels revolve fast and throw heavy seeds over a width as great as 50 feet, or lighter seeds such as timothy about 70 feet.

Wide-track broadcast seeders are commonly furnished in 11-foot width, with a seed hopper holding about 6 bushels. Seeders of this type are light draft and provide a fast method of distributing seed, but the seed must then be covered with another implement such as a harrow or weeder.

All kinds of grain can be sown with this type of seeder. The seeding rate is adjustable. Fluted seed wheels (p. 121) are used.

The *cultivator and broadcast seeder* is designed especially

for use in rough, stony ground and in stump land. With this type of seeder, the soil is cultivated and the seed covered. When desired, the seeding mechanism may be thrown out of operation and the machine used as a cultivator only. When obstructions are encountered, a spring trip permits the cultivator tooth to bend backward and pass over and then return to its working position.

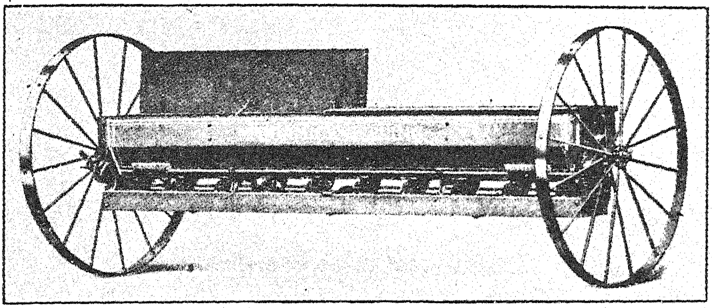


FIG. 78. A standard type of broadcast seeder.

GRAIN DRILLS

Drills are preferred to broadcast seeders in most grain-growing regions. They give the following advantages:

1. Control of the depth of seeding.
2. Uniform distribution of the seed in evenly spaced rows.
3. Covering the seed and firming the soil about it, if desired.
4. Less seed is required per acre when drilling than when broadcasting, as the seed is distributed uniformly and at proper depth.

Broadcast seeders, however, are light, fast and comparatively cheap. They are useful on rough and stony land where the more intricate working parts of a drill might be damaged.

Grain drills are used more extensively than seeders. The

drill is equipped with furrow openers; the seeds are conducted through tubes to the bottom of a small furrow, and then covered by means of an appropriate covering device. The distance between seed rows varies from 6 inches to 12 inches, depending upon the spacing of the furrow openers.

It is also necessary that a drill be constructed to sow accurately large seeds such as peas or small seeds such as flax. The quantity of seed desired per acre also varies greatly. Fifteen to 20 pounds per acre of flax is commonly used, but as much as 90 pounds of oats is often sowed per acre. The drill must be provided with the proper adjustments to make these changes possible.

In many sections it is customary to apply fertilizer when seeding. For this purpose the seed box of the drill is made into two compartments, one for the seed and the other for the fertilizer. Drills designed for this purpose are called *fertilizer drills*. The term *plain drill* refers to drills that do not drill in fertilizer with the seed.

Types and Sizes

The size of a grain drill is determined by the number of seed tubes or furrow openers used. One of the most popular sizes has twenty furrow openers, spaced 6 inches apart. This drill would cover 10 feet of ground with each trip over the field. The size of this drill is expressed as 20 by 6. Seven-inch and 8-inch spacing of the furrow openers is also used.

Drills may be obtained with as many as twenty-eight furrow about 5 feet in width and is equipped with ten furrow openers; the twenty-four furrow opener size requires four or five horses or a tractor.

One-horse Drill. The one-horse drill is often used for planting grain between rows of corn or cotton. With its five disks set for 6-inch rows, this drill sows a swath of 30 inches. A lever is provided to change the spacing to 7 or 8 inches, if desired.

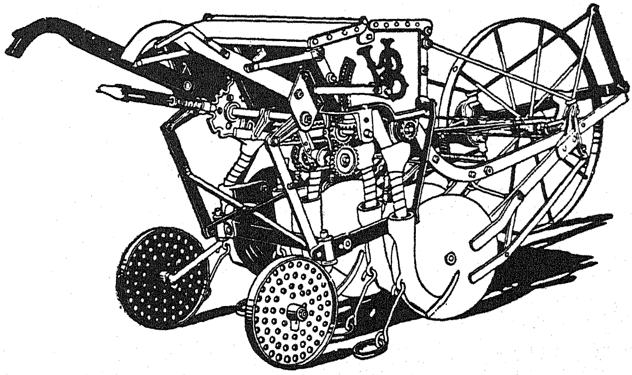


FIG. 79. One-horse grain drill with fertilizer attachment.

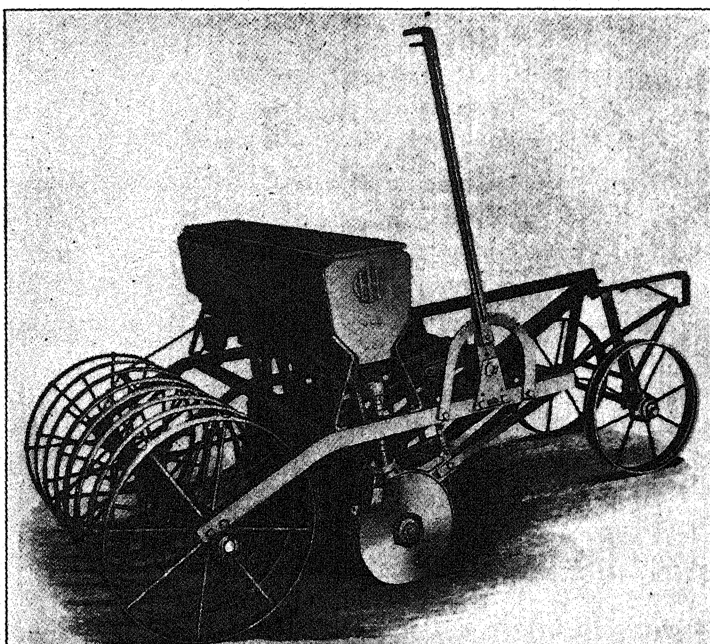


FIG. 80. Plow press drill.

Plow Press Drills. Several manufacturers now produce drills for use immediately behind the plow, thus combining plowing and seeding. Heavy press wheels follow furrow openers, and firm the soil over the seed. Plow press drills are available for seeding widths of 42 to 60 inches, and are adjustable to the width of plowing. The seeding mechanism of the drill is operated by a chain from the press wheels.

Standard Horse-drawn Drills. The number of furrow openers furnished on the various sizes range from five to as many as twenty-eight. Five would be a load for a single horse and twenty-eight would require six horses; a drill with twelve furrow openers is usually operated with three horses. A typical five-opener fertilizer drill weighs approximately 370 pounds, a twelve-opener fertilizer drill 1100 pounds, and a twenty-eight opener plain drill approximately 2200 pounds.

Horse-drawn drills are supplied with hand levers for raising the furrow openers. The larger sizes, with eighteen or more furrow openers, are available as plain drills only. Fertilizer drills may be secured in the smaller sizes. Fertilizer attachments may be secured and attached to rear of grain hopper.

Tractor Drills. Horse-drawn drills may be supplied with a tractor hitch and otherwise adapted for operation with a tractor.

Furrow openers, when spaced 6 or 7 inches apart, are usually arranged in zigzag or staggered ranks. When spaced wider, 8 to 16 inches apart, they are arranged in a straight line only.

Tractor drills are usually furnished with a power lift similar to that used on the trailed plow (p. 35) and a depth-regulating device which can be adjusted from the tractor seat.

Deep-furrow Drills. Tractor drills with furrow openers spaced 10 inches, 12 inches, 14 inches or 16 inches are called *deep-furrow* or *semideep-furrow*. Single-disk furrow openers of 16-inch diameter are used. They open a seed furrow 3 to 4 inches deep, deposit the seed in the bottom of the furrow, and

cover it lightly, with a portion of the soil thrown out by the disk. Some soil remains as a ridge, adjacent to the seed row. Thus the rows of seed lie in a deep trench or depression protected at each side by a ridge. In dry regions especially, this method insures earlier and more uniform germination and bet-

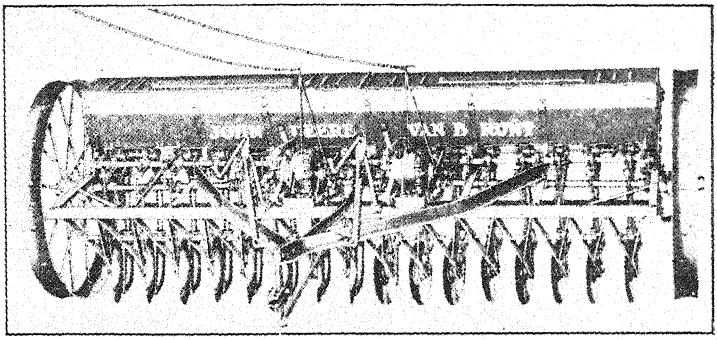


FIG. 81. Tractor drill with power lift.

ter root development. The alternate trenches and ridges catch snow and rain and lessen the destructive effects of soil blowing.

Construction and Principal Parts

Frame. The frame is usually constructed of angle steel. Figure 82 shows a closed-end drill frame. The frame should be well braced and strong, as it must hold all parts in proper alignment. It is the base of the drill, and all other parts are connected to it. The corners are reinforced, and the angle cross ties stiffen and strengthen the frame.

Axles. There are two types of drill axles, the one-piece or continuous axle, which runs the full length of the frame, and the two-piece or stub axle. The axles are attached to the underside of the frame. Drill axles are "live axles," that is, they turn with the wheels. Suitable bearings are provided for the axles at several points along the drill frame. Power is

taken from the revolving axle to drive the feeding mechanism of the drill.

The outer ends of the axle are usually provided with roller bearings. As most of the weight of the drill is carried on them, these bearings should be of ample size and should always be kept well lubricated.

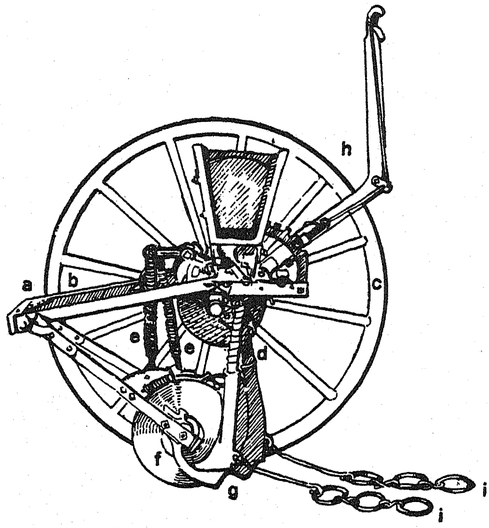


FIG. 82. Cross section showing construction of the grain drill.

Wheels, Ratchets, and Pawls. The wheels (Fig. 82*c*) may be made of wood or steel. They are provided with a wide tire (3 or 4 inches) to prevent their sinking deeply into the soft seed bed.

Where the long, one-piece axle is used, the wheels are connected to it by means of ratchets and pawls. The pawls (Fig. 83) are held by rivets to the hub cap. The hub cap is fastened securely to the axle by a pin, which passes through the hole in the hub cap. The inside of the hub of the wheel has a series of notches or teeth which engage the pawls. These are shaped so that, when the wheels turn forward, the pawls and

hub cap revolve with them. The hub cap, being securely pinned, causes the axle to turn with it. Thus the forward motion of the wheels not only transports the machine but also is the source of power for driving the seeding and fertilizer-feeding mechanisms.

The reverse motion of the wheels, when the drill is backed up, causes the notches in the wheels to slip over the pawls without engaging them. Thus, when the drill is backed up, the axle does not turn and the feeding mechanisms do not operate. When the drill is turned around, the wheel on the outside of the turn drives the axle, while the one on the inside slips over the pawls. The action on a turn is similar to that of a differential.

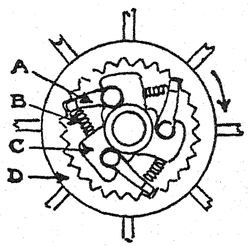


FIG. 83. Pawls, springs, and ratchet.

This construction is referred to as a *ratchet drive* or *ratchet and pawls*. It is used on many farm machines and should be clearly understood by the student. The construction is simple and gives little trouble when the parts are new and properly fitted to each other. As the machine is used and the parts wear, the ratchet is likely to slip over the pawls. The pawls and pawl springs must be renewed frequently. Sometimes the pawls come loose while the machine is in operation, usually because the hub cap, which carries the pawls, is not tight against the wheel that carries the ratchet or teeth. There is usually an adjustment provided to keep these parts snugly together. In some drills, two or more holes are drilled through the hub cap. If the pin is put through the outer hole the two parts are drawn tighter together.

Where two-piece or stub axles are used, the ratchet and pawls are not necessary, the wheel being pinned directly to the axle. Each wheel and axle is independent of the other, and each drives one-half of the feeding mechanism of the drill. These mechanisms are built in halves.

Seed and Fertilizer Hoppers. The seed and fertilizer hoppers are carried on top of the frame toward the rear. The front compartment carries the seed, and the rear compartment the fertilizer.

The interior construction of the seed hopper is illustrated in Fig. 84. The metal bridges (*a*) deliver all the grain to the feed cups (*b*). These bridges prevent the accumulation of unseeded grain at the bottom of the box.

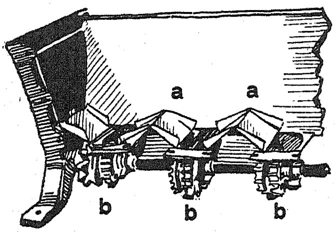


FIG. 84. Interior view of one type of seed hopper.

Truss rods are used on large drills to reinforce the hopper and to prevent its sagging in the middle.

Grain-feeding Devices. There are two principal types of grain-feeding devices used on drills.

1. *Fluted Force Feed.* Figure 85 shows a fluted force-feed cup. One of these cups is provided for each furrow opener. They are attached to the bottom of the seed box. The fluted feed wheel revolves with the square feed shaft (Fig. 85*a*). The recesses in this wheel are filled with grain, which is delivered as indicated.

The deflector lip (*b*) cleans the wheel and prevents the grain from being carried back into the seed cup.

The cut-off, or follower (*c*), enters the feed cup through slots cut in one side. Its function is to shut off a portion of the feed cup so that the amount of grain to be sowed per acre may be regulated. The fluted wheel and the follower may be moved together in or out of the feed cup by means of the feed-regulating lever. The position of the adjustable gate at the bottom of the feed cup may be changed as required for the various sizes of seeds to be planted. In some drills this gate may be entirely opened for sowing large seeds, such as peas

or corn, or for convenience when cleaning out the seed box of the drill.

2. *Double-run Force Feed.* This type of feed cup is illustrated at C in Fig. 86. Both sides of the wheel (C) are ribbed or fluted. One side has small recesses and is used for sowing small grains. The other side of the wheel has larger spaces and is used for sowing the larger seeds such as oats or beans. One wheel is provided for each furrow opener. The entrance to the side not in use is closed by means of a hinged metal lid in the bottom of the seed hopper (A).

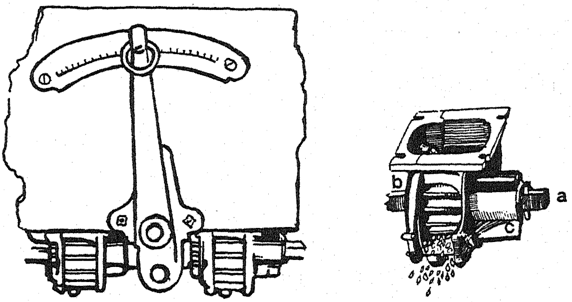


FIG. 85. Fluted force feed.

The entire surface of the grooves in the feed wheel is always in contact with the grain, in this type of feed. The rate of seeding is controlled by varying the speed of the shaft which drives the ribbed feed wheels. A study of Fig. 86D will show how this is accomplished. A large multiple gear, with several rows of teeth (a), is carried on the axle. Setting the sliding gear (b) toward the center of the large multiple gear will transmit a comparatively slow motion through the gears and chain to the square feed shaft (c). This causes the ribbed feed wheels to turn slowly, with the result that the amount of seed per acre is small.

If the sliding gear (b) is set at the outer edge of the multiple gear, the rate of seeding is increased. There are usually

from six to ten different settings possible on the multiple gear.

Two sizes of sprockets are furnished for use at *d*, Fig. 86*D*.

Reducers (Fig. 86*B*) are often used in feed cups to cut down the rate of seeding. These are metal pieces which are pressed into the bottoms of the seed cups. They decrease the size of the opening to give better control of the seeding rate of small

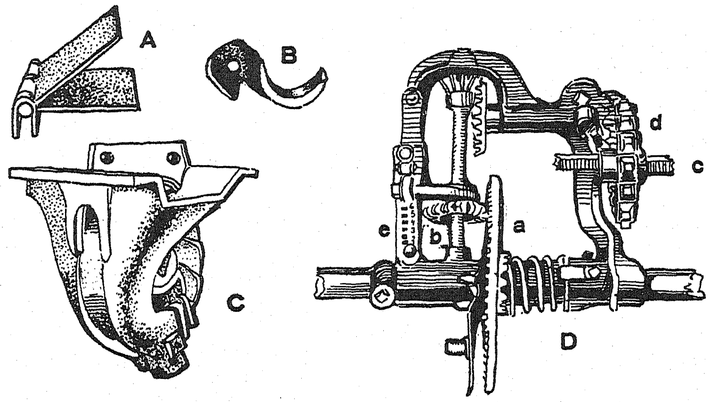


FIG. 86. Double-run type of grain-feeding device.

grains. The reducers are removed with a small wire hook, when not in use.

Seed Tubes. The seed tubes (Fig. 87) are made of ribbon steel. They are fitted at the upper end with a pressed steel cup which is attached to, and encloses, the feed cups at the bottom of the hopper. This metal cup may have three tubes or branches leading into it: one for the seed, one for the fertilizer, and one for the grass-seed attachment. Grass seed is often planted with the drill.

The function of the seed tube is to conduct the seed and the fertilizer from the hopper down to the furrow opener. It should provide a straight and smooth passage for the seed, and should enclose and protect it from the scattering effect of the wind. The entire seed tube can be removed easily without the use of tools.

Furrow Openers. Four types of furrow openers are used. They all have the same function, namely, to open a furrow of the desired depth, into the bottom of which the seed is dropped. The best type to use depends upon field conditions.

Hoe Furrow Opener. This is the oldest type in use. It is furnished with a double-pointed shovel. If this shovel is kept sharp, good penetration may be secured. One objection to the hoe furrow opener is that it tends to become clogged in a trashy field, but it is the simplest and perhaps the most durable of all types.

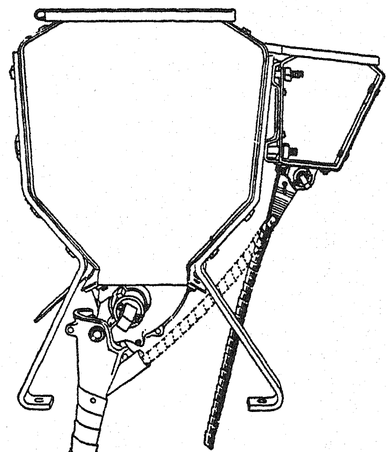


FIG. 87. Seed tubes and grass-seed attachment.

Spring trips are usually provided, so that the hoes are automatically released if an obstruction is encountered. Hoes with wooden break pins (like those used on cultivators) may also be secured. Penetration is increased by means of a pressure spring. The amount of downward pressure exerted by this spring is controlled by the lifting levers.

All types of furrow openers are provided with pressure springs, but the point at which the pressure is applied varies on the different types.

Hoe furrow openers may be assembled in a straight rank, or they may be in zigzag rank like the single-disk furrow openers shown at *d* in Fig. 82. The zigzag placement is best for trashy fields since it gives more clearance between the hoes. The angle of the hoe opener is adjustable. It is the most satisfactory type for use on rough, stony ground.

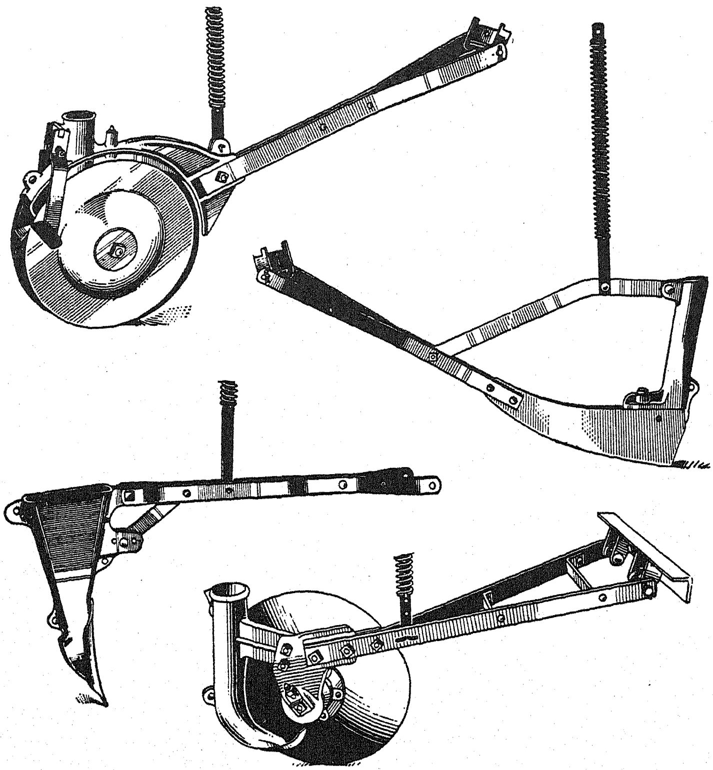


FIG. 88. Drill furrow openers.

Shoe Furrow Opener. This furrow opener is usually assembled on the drill in zigzag rank. The blades are made of high-carbon steel and may be resharpened on the anvil when dull. They scour well, and if properly adjusted will not give trouble

in trashy fields. The draft of the drill is much reduced by the use of shoe furrow openers.

An adjustment is provided for raising or lowering the forward end of the shoe. This adjustment is useful in preventing the nose of the shoe from picking up trash. The pressure spring is attached as illustrated and the pressure is regulated by the setting of the lifting lever. The lower end of the seed tube enters into the boot which conducts the seed directly to the bottom of the furrow.

Single-disk Furrow Openers. The disks are arranged in zigzag rank. One-half of the disks throw the soil toward the right, and the other half toward the left side of the drill.

The seed boot is placed on the convex side of the disk. It should reach well down toward the bottom of the disk so that the seed will be deposited in the very bottom of the furrow.

The pressure spring is attached as indicated, and pressure is regulated by the setting of the lifting lever. The tension of each pressure spring is also adjustable. One method of adjusting this is by means of a wire hook at the bottom of the spring. By moving this hook to a higher hole the spring is raised and compressed. Thus the pressure on the furrow opener is increased. Pressure springs may be made in two pieces, so that one part threads around the coils of the other. The pressure is increased by turning the coil up, and decreased by turning it down.

As the disks revolve when the drill is in operation, they must be provided with a bearing. This should be well designed, carefully made, and properly lubricated. The location of the bearing is such that it operates continually in a cloud of dust and grit. It should be dustproof and oiltight. Figure 89 shows the construction of the bearing of a single-disk furrow opener. The disk hub (2), which is riveted to the disk, revolves on the stationary bearing block (5). The assembly is sealed by a belt and a sponge-rubber seal (3) and by gaskets (4 and 6). Lubrication is forced into the bearing through the hydraulic fitting shown.

Both sides of the disks are provided with scrapers. The scraper at the lower end of the boot cleans the convex side of the disk. The scraper for the concave side is adjustable and may be locked clear of the disk when not needed.

The single-disk furrow opener is widely used. It penetrates well and gives the ground an additional cultivation. It cuts

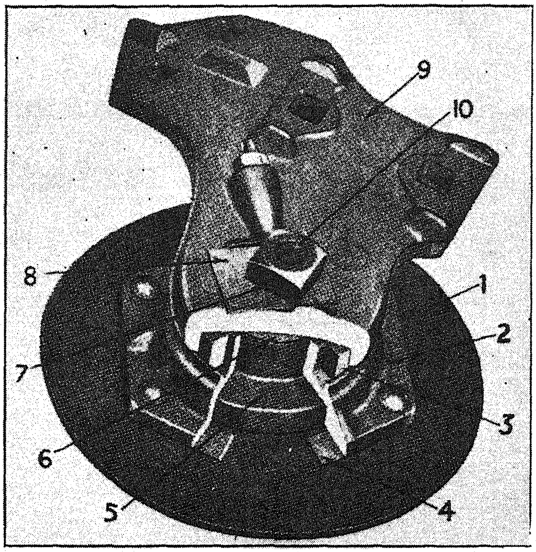


FIG. 89. Bearing of single-disk furrow opener.

through trash easily and is often used for drilling grain into fields of corn stubble that have not been plowed.

The single-disk furrow opener has more wearing and moving parts than the hoe furrow opener. The action of the single disk throws all the soil to one side so that the drag chains cover the seed almost entirely with soil from one side. Single-disk furrow openers cause heavier draft because of the thorough manner in which they work the soil.

Double-disk Furrow Opener. The two disks are usually flat blades of steel set at an angle to each other. They meet at the

front, with one extending slightly ahead of the other. This causes better penetration. The spread at the rear of the disks causes them to open a furrow 1½ to 2 inches wide.

The double-disk does not penetrate as well or cultivate the ground as thoroughly as the single-disk. It covers the seed somewhat more evenly and the draft is lighter. The inside and outside scrapers prevent clogging on wet or sticky fields. The single-disk opener cuts through trash better than the double-disk.

Covering Devices. Drag chains are commonly used for covering the seed. They are hooked into the rear of the seed boot. One chain is provided for each furrow opener.

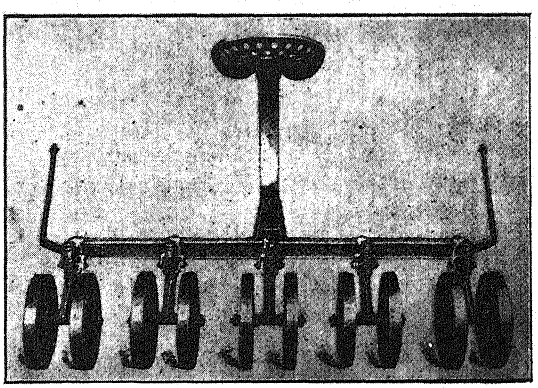


FIG. 90. Press-wheel attachment for standard high-wheel drill.

Drag chains are used with all of the types of furrow openers mentioned above. They cover the seed well but do not pack or firm the soil above it.

In sections where it is desirable to conserve the soil moisture carefully, and during dry seasons, the press-wheel drill is used (Fig. 80). In this drill, press wheels replace the high wheels of the standard drill. The feeding mechanisms are driven by a chain from the press wheels.

Press-wheel attachments may also be secured for the stand-

ard high-wheel drill. One press wheel follows each furrow opener and firmly packs the soil above the seed. (See Fig. 90.)

Fertilizer-feeding Device. The most commonly used fertilizer-feeding method is called the *finger feed.* The location of the fingers in the bottom of the hopper is shown in Fig. 91. One wheel (*b*) is provided for each furrow opener. It is seated into a bevel gear on the bottom of the fertilizer hopper. The bevel gear meshes with a small pinion which is connected to the fertilizer-feed shaft (see *c* and *d*).

As the fingers revolve, the space between them fills with fertilizer. These small loads of fertilizer are carried toward the adjustable gate (*e*) which controls the size of the opening to the fertilizer outlet. The gates are regulated by an adjusting lever which makes possible twenty-five to thirty-five settings of the gates.

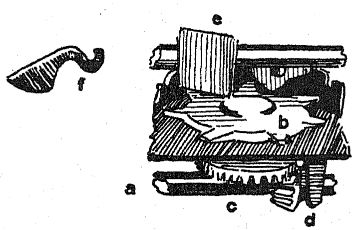


FIG. 91. Fertilizer feeding device.

The amount of fertilizer required per acre is subject to great variation. Fertilizer feeds, therefore, must have a wide range of adjustment. Many fertilizer drills may be adjusted to sow 50 to 1100 pounds of fertilizer per acre. This adjustment is accomplished by the setting of the gates, as mentioned above, and also by varying the speed of the fertilizer-feed shaft. The speed of this shaft may be regulated by means of a change of the gears, which provide at least two speeds. The fertilizer-feed shaft is driven from the drill axle by a chain.

Lifting Devices (Fig. 82*h*). On horse-drawn drills, levers are provided for raising and lowering the furrow openers. Each lever raises one-half of the furrow openers. Tractor drills are furnished with a power lift. This is operated by a rope from the driver's seat on the tractor and is quite similar in construction to that used on plows.

Clutch. A simple type of toothed clutch is placed on each end of the main axle. Lowering the furrow openers engages these clutches so that the feeding mechanisms begin to operate as the furrow openers are lowered. In some types of drills it is possible to disengage the clutch when the furrow openers are down. With disk drills this is convenient because it is frequently desirable to disk without seeding or to seed with only one-half of the drill.

Grass-seed Attachments (Fig. 87). A small hopper for grass seed may be attached in front of the main hopper. A small tube conducts the grass seed to the main seed tube and plants it with the grain or, if desired, the grass seed tubes may be arranged to deliver the grass seed in front of or behind the furrow openers.

The grass-seeding attachment is driven from a sprocket on the main axle. The construction of the hopper and feeding mechanism is very similar to that of the grain drill.

Poles and Tongue Truck. Small grain drills are usually furnished with one pole. Drills of 8 or more feet have two poles and are equipped with four-horse eveners. A drill with a tractor hitch is shown in Fig. 81.

Tongue trucks or forecarriages may be secured. They are particularly desirable when several drills are drawn behind one tractor.

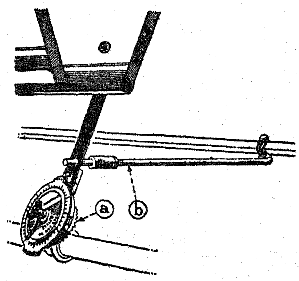


Fig. 92. Surveyor or land measure.

Surveyor or Land Measure (Fig. 92). A surveyor, or land measure, is usually provided. It is driven from a worm on the main axle, which drives a gear on the back of the surveyor (*a*).

The surveyor operates only when the drill is seeding. The movement of the drill axle causes the dials of the surveyor to turn very slowly. A certain number of turns of the drive wheels

will move the drill far enough to seed one acre, and will move the dial hand through a space marked 1, or 1 acre, on the dial. The dial reads in acres and fractions of an acre. The surveyor is very useful in enabling the operator to keep a careful check on the quantity of seed per acre. A throwout arm (*b*) throws the surveyor out of action when the furrow openers are raised.

JOB 9

TO REPAIR A GRAIN DRILL

Procedure

1. Get the owner's and operator's report on the condition of the drill; field troubles; worn, broken or missing parts; faulty adjustments; name of the manufacturer; year of purchase; and the repair catalog and instruction book which were furnished with the drill.

2. Test and inspect carefully, noting each worn or broken part.

Jack up one side, and test the working parts, by turning the drive wheel. If the grain-feed or fertilizer-feed shafts are stuck tight, loosen by turning them directly with a wrench, instead of attempting to force them with the drive wheel. Test the bearings of disk furrow openers.

3. List all repair operations required.

4. Order repair parts.

5. Clean and repair the hoppers, seed tubes, grain and fertilizer feeds. Fertilizer accumulated between gear teeth frequently causes them to break. If the accumulated fertilizer has become hard, it may be softened and washed off with warm water. Lubricate the bearings of the shafts and gears that operate the grain and fertilizer feeds.

6. Test and repair the pawls, ratchets, and wheels. Remove the wheels from the main axle. Clean and lubricate the main-wheel bearings. Examine the pawls and replace any that are worn or broken. Check the tension of the pawl springs and re-

place weak springs. In some drills the ratchet is a replaceable part, but in others it is part of the main wheel.

When replacing the hub caps be sure the pawls are properly engaged in the ratchet of the wheel and that there is a slight looseness, or end play, between the wheel and the hub cap. Jack up one wheel and put the feeding mechanisms in gear. Turn the drive wheel and determine how quickly the feeding mechanisms start working. Lost motion at any point, between the drive wheel and feed cups (or fertilizer fingers), is serious. It is likely to cause blanks (unseeded spots) in the field. Such lost motion is caused by looseness, or wear, in the gears, sprockets, or chains, transmitting power from the drive wheel to the feed cups. It is frequently caused by worn pawls, clogged or worn ratchets, or weak pawl springs.

Adjust the inner end of stub axles so that top of the drive wheel slants slightly away from the hopper. (This adjustment cannot be made on drills that have the one-piece axle.) As the drill wheels and their axles wear, they spread apart at the bottom or where they bear on the ground and come closer at the tops. Sometimes due to neglect, this wear becomes so great that the wheels rub against the hopper. The removable boxes, if provided at the hub of the wheel, should be replaced.

7. Adjust the pressure springs. Replace any that are broken and adjust all to equal tension.

8. Adjust the furrow openers. Raise the furrow openers and test each one for loose connections. Connections may loosen at the drag bar, between the seed boot and the drag bar, or at the frame of the drill. Uneven and ragged seeding results. Tighten all such connections.

9. Repair disk bearings; remove the disks; clean and lubricate the bearings. Test the bearings for looseness and replace any that are worn. A loose bearing causes the disk to wobble, with resultant poor seeding. Be sure all oil tubes are clean.

10. Repair disk scrapers. Scrapers receive hard usage and should be replaced frequently. The springs, which maintain the tension of the scrapers against the disks, may need replace-

ment also, or the tension of weak springs may be restored for a short time by stretching the spring. Adjust the scrapers to conform to the surface of the disks.

11. Adjust the balance springs (attached to the lifting lever) so that this spring pressure is sufficient to help raise the furrow openers when the lever arm is "past center" in the upward position, and also to help force them down when the lever arm is "past center" in the downward position.

12. Repair the covering device. Drag chains are often lost in the field. They should be replaced and all links properly closed to prevent further loss. Examine and repair the bearings of press wheels as required.

13. Clean and adjust drive chains. Loosen the chain tighteners and remove the drive chains. Wash them in kerosene and then determine whether they are fit for further service. (See p. 338). Dip the chain in oil and assemble and adjust it correctly.

14. Paint all parts, except the polished steel surfaces of the furrow openers. These should be covered with a thick coating of grease to prevent rust.

Operating a Grain Drill

Hitch Adjustment. The vertical hitch should be adjusted so that the grain hoppers will be level when the drill is in operation. If the grain hoppers are level, the frame and furrow openers will have the correct working angle. This may be regulated by the neckyoke straps where horses are used, or at the connection between the pole and the frame. On tractor drills the necessary adjustment may be made at the stub tongue or tongue truck (if used), or in some cases on the drawbar of the tractor.

If the pole is too high, the rear of the drill will be lowered. This causes too deep planting and covering. If the front end of the pole is too low, the seed will not be planted deep enough or will not be thoroughly covered.

The horizontal hitch is arranged to eliminate all side draft.

As the drill is wider than the power unit, the center of power—whether horses or tractor—may be connected to the exact center of the implement.

A standard type of tractor hitch with power lift and pressure-regulating cranks is shown in Fig. 81. Power-lift trip ropes on the two-drill hitch (Fig. 93) enable the operator to control and operate both drills.

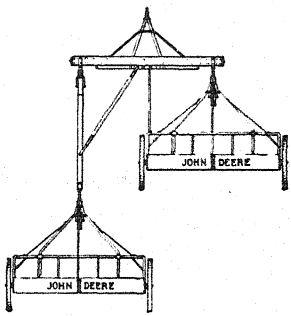


FIG. 93. Two-drill tractor hitch.

Procedure

1. Distribute sacks of grain and fertilizer along the ends of the field so that the hoppers may be conveniently filled as required. Be sure the hoppers are sufficiently full to complete the trip across the field. If they become empty in the field, it is difficult to find the exact spot where the seeding stopped, and an unseeded space may be left.

2. Adjust the seed and fertilizer regulators to get the desired quantity per acre. Fill the seed and fertilizer hoppers. The amount of seed to use per acre depends upon the climate, the fertility of the soil, the amount of rainfall, the size of the seed, and many other factors. It is a problem that should be given ample study, and the results of the various regional customs should be carefully observed. The amount of fertilizer to be used per acre also depends upon a variety of factors.

The methods of setting the rate of seeding and sowing fertilizer have been thoroughly discussed in this chapter and are explained in the seeding tables furnished with the drill.

3. Set the surveyor or land measure at zero before each new field is started. This is done by loosening the nut that holds the dial hand and turning the hand to zero. This adjustment is important because it gives the operator a means of checking the rate of seeding.

4. Lower the furrow openers and start across the field with the drill seeding just inside the space desired for a headland.

Headlands, or turning strips, are left at each end of the field and are seeded after the main part of the field has been completed. Seeding is begun at one corner. The drill is driven straight across the field, seeding as it goes. When the headland at the opposite side is reached, the furrow openers are raised. The drill is turned entirely around on the headland. The furrow openers are lowered again after the turn is complete, and the drill is in position to start the seeding for the return trip across the field. On the return trip, have the drill wheel on the inside of the strip lap over the wheel mark made on the first trip across. If this is done carefully there will be no "skip" or unseeded strip between succeeding trips.

Depth of Seeding

The pressure lever or crank controls the depth of seeding. On hard ground the tension of the pressure spring on each individual furrow opener may be increased. In very loose soil the weight of the furrow openers alone is often sufficient to give the necessary penetration.

Adjustment of Balance Springs

These springs assist in raising the furrow openers. The tension should be adjusted to give easy lifting but should not be tight enough to interfere with lowering the furrow openers.

Drilling Row Crops

Grain drills are frequently used for planting corn, beans, sugar beets, soybeans, and other cultivated row crops. The width between rows is regulated by shutting off the flow of grain and fertilizer through certain furrow openers. For this purpose, some grain hoppers are furnished with double flaps, as shown at *A* in Fig. 86. If one flap is turned left and the other right, neither side of the double-run feed will receive grain. Feed stops for the grain and fertilizer hoppers may be secured for other types of drills. A plan for obtaining 28 inches or 42 inches between rows is indicated in Fig. 94.

An adjustable marker is necessary when planting row crops. The tractor is centered on the mark and gives the correct distance between rows made on adjacent trips across the field. Markers are also desirable for seeding grain when a wide drill or a two-drill combination is used.

Fertilizer Placement

The usual custom is to drill the fertilizer through the steel-ribbon seed tube. Special fertilizer tubes and spouts may be secured which separate the seed and fertilizer delivery and lessen actual contact between them.

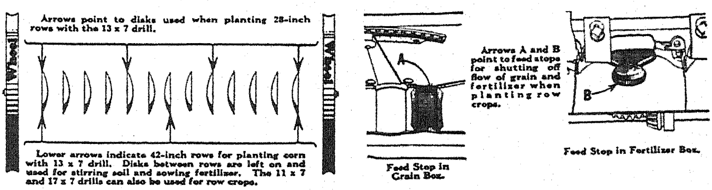


FIG. 94. Use of drill for planting row crops.

Drilling is more accurate than broadcasting. Less seed is required, the seed is covered more evenly, and germination and growth are more nearly uniform. The results of many experiments indicate that the yield is better with drilled seed than with broadcast seed.

Grass Seed and Alfalfa Drills

Drills designed especially for sowing alfalfa, clover, timothy, and similar small seeds are quite similar to the grain drill in general construction. Furrow openers, however, are spaced more closely—4 inches apart—and the seed cups are smaller. Hopper capacity is about 2 bushels.

Beet and Bean Drills

They are especially designed for multiple-row planting of such crops. They are equipped with press wheels, markers, and depth gauges, and may be obtained as either plain or fertilizer drills. A pressure spring is provided for each furrow opener and each press wheel.

CHAPTER IV

ROW-CROP SEEDERS AND PLANTERS

Seeders for row crops vary from single-row units to multiple-row combinations for six or more rows. The distance between rows is greater than with grain seeders. There is much variation in the size and shape of the seeds of the different row crops.

Because of the commercial importance and large acreage of the major crops, certain planters are designed primarily for one crop, such as corn, potatoes, cotton, etc. Yet, because owners of small acreages may raise several different crops, some seeders are capable of planting accurately many different kinds and shapes of seed.

Vegetable Seeders

Types and Sizes. The one-row, hand-propelled garden seeder weighs about 35 pounds, and the seed hopper has a capacity of approximately 4 quarts.

The seeding mechanism comprises a unit, complete with seed hopper, furrow opener, covering device, and press wheel. Such complete units are easily combined into multiple-row gangs to be drawn by horses, garden tractors, or farm tractors.

Seeding Unit. The front wheel not only is a carrier or transport wheel but also furnishes power for driving the feed shaft. The feed shaft extends into the hopper and drives an agitating bristle brush or wave-shaped, metal feed wheel. The feed wheel revolves over the outlet hole in the seed plate and forces the seed out of the hopper through the seed-plate hole, down through the seed boot to the rear of the furrow opener. It acts also as an agitator to prevent clogging.

The rate of seeding—number of seeds per foot—is regulated by placing the seed hole of correct size below the hopper outlet. The hole size needed depends upon the size of seed and the quantity desired. Seeding units are commonly furnished with three seed plates, each having thirteen holes of different diameter. Thus, thirty-nine outlet openings are provided. The seed plates are locked in position and do not revolve when the seeder is working. But, when a different seeding rate is

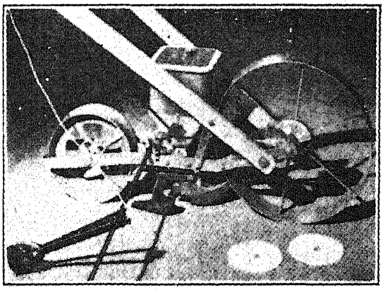


FIG. 95. Garden seeder, with marker and extra seed plates.

required, the locking device is loosened and the seed plate is revolved until the desired opening is below the hopper outlet. The hopper itself may be removed easily to change seed plates or to discharge unused seed. Tables, with directions for sowing definite quantities of various seeds, are furnished with the seeder.

A shut-off valve in the hopper stops the seed flow whenever forward motion stops, otherwise some fine seeds might continue to flow, even with the seeder not moving. The shut-off valve is controlled from a rod on the handles, or it may act automatically whenever the furrow opener is raised from the ground.

Furrow openers are adjustable and may be set to a depth of 1½ inches. The coverers also are adjustable. The rear wheel acts as a press wheel for further covering or firming the soil over the row. It may be obtained with flat or concave rim. The

marker is adjustable for marking rows of various width, and functions at either the right or left side of the seeder.

Attachments and Special Equipment. Although most vegetable crops are drilled, a hilling attachment is available. The fertilizer attachment (Fig. 96) holds as much as 10 quarts. Accurate control of the amount and placement is possible, and modern designs eliminate the danger of fertilizer injury caused by too close contact between plants and fertilizer.

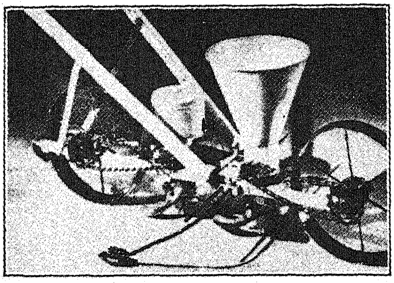
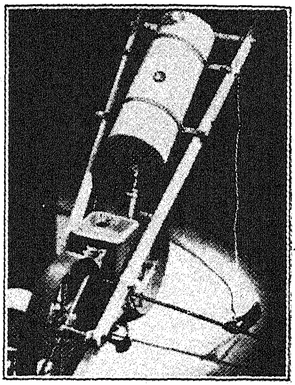



FIG. 96. Attachments for garden seeders.

An attachment to flow formaldehyde solution on the seed as it is planted is shown in Fig. 96.

Sleds for planting two accurately spaced rows on beds or ridges are used in some market garden regions. Two seeders mounted and accurately spaced in the sled give twin rows of such uniformity that the close cultivation later required is easily performed.

Single- or two-row seeding units designed for attachment to cultivator frames or for making up special multiple combinations are available.

Certain hand seeders are designed for the easy removal of the seed hopper and other seeder parts and for the mounting of cultivating equipment on the seeder frame and carriage.

The disk-ridger attachment covers the seeder more thoroughly and hastens germination. Before the green plant breaks through the ground the ridge is raked off, leaving the surface clean and free from weeds.

Corn Planters

Corn planters may be divided into three classes, as follows:

1. Drill planters.
2. Lister planters.
3. Check-row planters.

The drill and the lister plant the kernels at regular intervals along the row. This method of planting is called *drilling*. Another method is to plant the corn in hills, with several kernels in each hill. Most corn planted in hills is put in with a check-row planter. The use of the check-row planter makes the hills line up both ways. For this reason, a field planted with a check-row planter may be cross-cultivated. It is possible to secure a hill-drop device for corn drills and listers. Such a device will plant in hills, but the hills do not "check" or line up both ways. Cross cultivation would be impossible with this type of planting. The check-row planter, however, can be used for drilling, hilling, and check-row planting, and accomplishes each style of planting equally well.

Most types of corn planters can easily be adapted for planting cotton, beans, peanuts, peas, and similar crops. All that is required is a change of the seed plates and the other parts of the hopper bottom.

Corn Drills (Figs. 97 and 98). The corn drill is the simplest of the three types. In the one-horse corn drill a steel runner, or shoe, is used to open the furrow for the seed. The kernels drop from the hopper through the metal seed tube to the bottom of the open furrow. The corn is covered by the main wheel, which tracks behind the seed tube. This wheel also drives the seed plate, which revolves inside the hopper. The

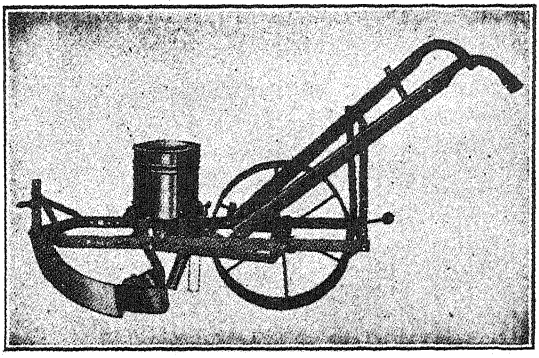


Fig. 97. One-horse corn drill.

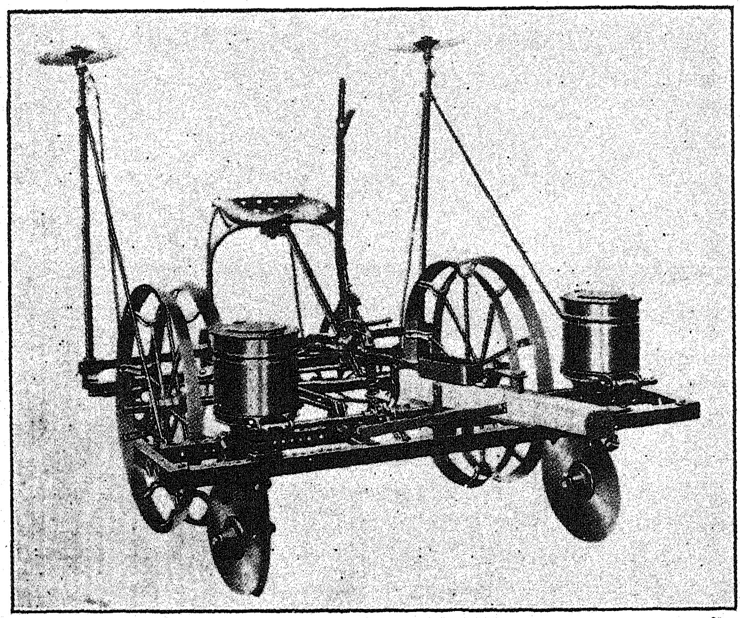


Fig. 98. Two-horse, two-row corn drill.

driving power is transmitted from the wheel to the seed plate by a pitman. The two-horse, riding corn drill plants two rows at a time. The width between the rows may be varied from 30 to 48 inches. The construction is similar to that of the one-row corn drill. A chain from the main axle turns a drive shaft that extends from one hopper to the other. Both seed plates are driven by this shaft. Each main wheel tracks behind a furrow opener and covers the seed.

Both the single-row drill and the two-row drill may be equipped with fertilizer attachments so that the fertilizer may be distributed when the corn is planted.

Corn drills are usually furnished with three sets of seed plates—one set for small, one for medium, and one for large kernels.

The interval between kernels, or the "drilling distance," may be changed by varying the speed of the seed plates in relation to the main wheel. This is accomplished by a change in the gears, sprockets, or pitmans used to drive the seed plates. Provision is made for making this change easily. Seed plates containing eight to sixty-four cells may also be secured. When combined with special driving sprockets, these plates make possible any desired distance between kernels.

Special seed plates may be secured for planting many other kinds of seed. Beans or peas may be planted with the corn drill at the same time as corn is planted.

Combination Cotton and Corn Drill. The one-horse walking planter is furnished with seed plates for many different crops. A fertilizer attachment is available. Some designs employ a duplex seed hopper; others employ an additional seed hopper with which a second crop, such as beans, may be planted in the hill with corn or, if desired, between hills. The cotton-picker wheel, with agitator, plants single seeds.

The seeding mechanism commonly used in cotton planters is shown in detail in Fig. 100. The fingers on the cone in the bottom of the hopper press the cottonseed down on the fluted

picker, which revolves in the opposite direction from the cone. The seeding rate is varied by changing the position of the

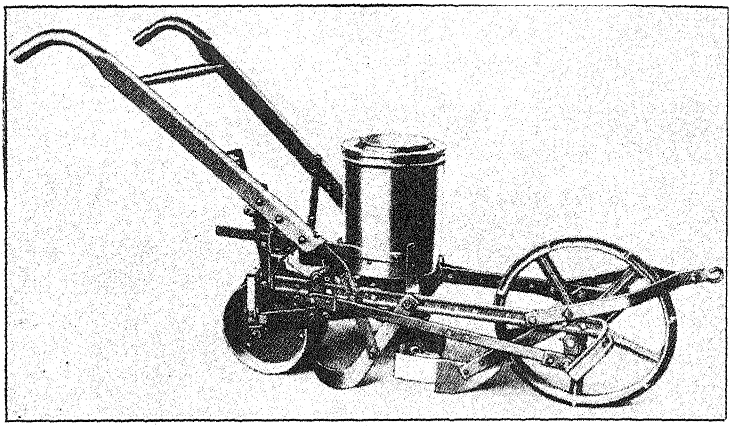


FIG. 99. Combination cotton and corn drill.

slide to bring more or less of the wide, fluted wheel into action.

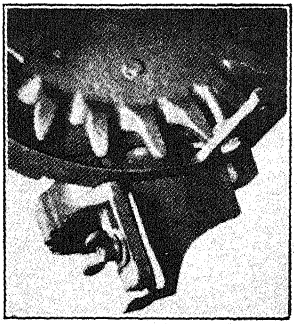


FIG. 100. Cottonseed picker wheel.

An adjustable, planting-depth gauge is carried on the runner furrow opener. The seed plate is driven by a pitman—or double pitman—from the rear wheel, and the fertilizer feed is operated by a chain from the rear wheel. Seed hoppers may be removed and seed plates changed without the use of tools.

Corn Listers. A two-horse, riding corn lister is shown in Fig. 101, and a walking lister in Fig. 102. The double moldboard of the lister throws the soil both ways, thus leaving an open furrow or trench for the seed. The seed is dropped from the hopper through the seed tube to the bottom of the open furrow. Two disks follow the seed tube and cover the seed.

A vertical steel blade will be noticed at the rear of the moldboard in Fig. 101. This acts as a rudder and prevents the lister from swinging to one side should the pressure on the

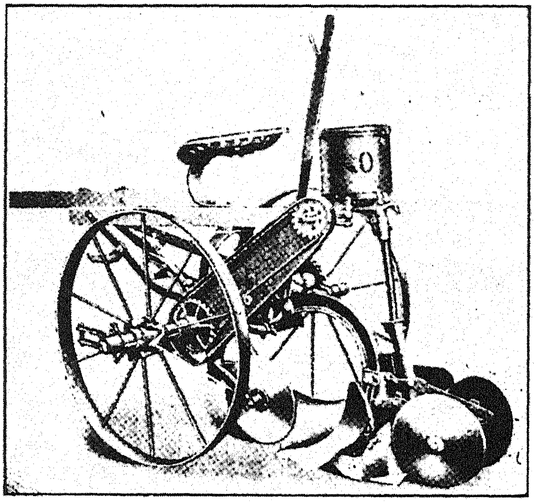


FIG. 101. Two-horse riding corn lister.

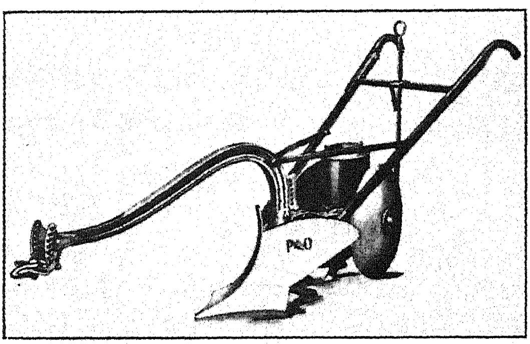


FIG. 102. Two-horse walking corn lister.

two moldboards be unequal. The small subsoil knife or plow in front of the disks penetrates and loosens the subsoil ahead of the seed tube.

The distance between kernels may be varied on the lister in the same manner as on the corn drill. Cotton or beans and many other seeds may be planted with lister by using special hoppers and plates.

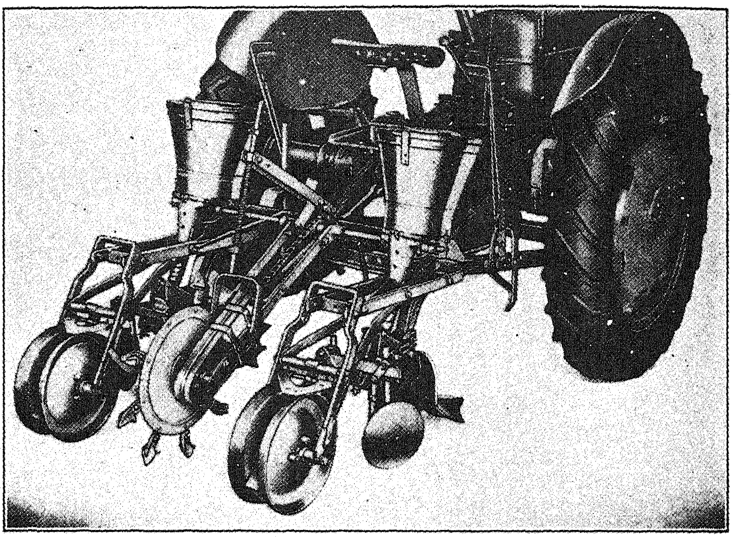


FIG. 103. Two-row, tractor-mounted corn lister.

The lister planter is used chiefly in dry regions, where it brings certain advantages, such as:

1. *Saving of Moisture.* The seed is planted at the bottom of the trench so that the plants take root deeply and use more of the subsoil moisture.

2. *Preventing of Soil Plowing.* The ridges left by the lister reduce this very effectively.

The two-row, tractor-mounted lister planter shown in Fig. 103 is equipped with shovel coverers and cast-iron press wheels. The feed shaft extending between the seed hoppers is driven by a chain from the ground wheel. The entire lister unit may

be raised or lowered by a power lift, and the planting mechanism is automatically thrown in or out of gear as the unit is raised or lowered.

A safety release permits the lister bottom to trip and swing backwards if obstructions are struck, thus preventing serious damage or breakage.

Check-row Corn Planters. The check-row corn planter is more widely used than either the drill or lister types, and, as the principles of its construction embody those used in the other types, it will be described here in detail.

This machine may be used to plant the corn in hills or to drill it in rows. It is called a check-row planter because, by the use of wire, the hills are planted at equal distances apart in each direction. The distance between hills in the same row is the same as the distance between rows. Corn planted in hills by means of the check wire may be cross-cultivated, which is advantageous in keeping the fields free from weeds.

It is possible to plant corn in hills, with this planter, without using the check wire. Corn is often planted this way. But if the check wire is not used, the hills will not be in line crosswise and, of course, cannot be cross-cultivated. The check-row planter, therefore, is adopted for three distinct styles of planting—drilling, hilling, and check-rowing.

The corn planter must be capable of adjustments, making it possible to vary the number of kernels planted in the hill. If it is used for drilling the corn, the distance between kernels must be controlled by adjustments provided on the planter. The distance between hills is determined by the distance between the buttons on the check row (Fig. 114).

The corn planter must open a furrow of proper depth for the seed, drop the seed to the bottom of the furrow at the proper rate or interval, and cover the seed in the furrow. In addition to this, the rows must be straight and at equal distances from each other.

Construction and Principal Parts

Wheels. The open-tire wheel (Fig. 104*a*) is the most popular type. Closed-tire wheels and double wheels are also used.

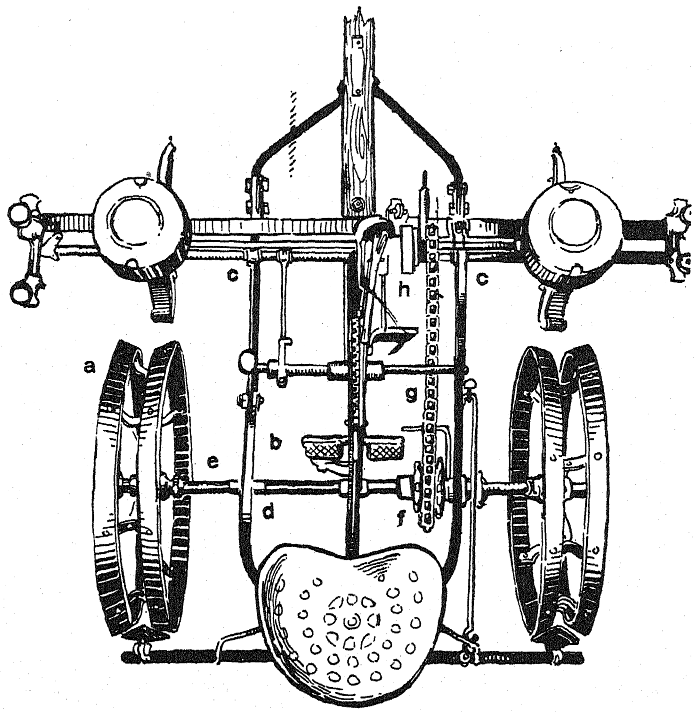


FIG. 104. Principal parts of the check-row corn planter.

One of the wheels is retained on the axle by means of two collars, one inside and one outside the wheel. These are adjustable so that the wheel may be lined up with the furrow opener.

The other wheel drives the axle and is bolted to it. Several holes are provided in the axle for the bolt so that the spacing of this wheel may also be regulated.

Main Frame (Fig. 104*b*). The main frame is usually made of a single piece of flat or channel steel which is bent into the shape shown. The holes in the front of the main-frame bars provide for attaching the main frame to the runner frame (*c*). Axle boxes are bolted to the main frame and carry the axle beneath it (*d*).

Axle (Fig. 104*e*). The axle is usually a hollow-steel tube 1 to $1\frac{5}{16}$ inches in diameter and about 50 inches in length.

Double or triple sprockets are carried on the main axle. A chain runs forward from these to the feed shaft of the planter. Sprockets of various sizes are used to change the rate of seeding as required. One sprocket for winding up the check wire and one for driving the fertilizer attachment are also carried on the rear axle. A clutch is usually placed on the axle to operate and control the sprocket which drives the fertilizer attachment.

Furrow-opener Frame or Runner Frame. The front ends of the main frame are bolted to the runner frame as shown in Fig. 104*c*. The runner frame extends across the planter and supports the seed hoppers and the seed-dropping plates. The runner frame is made of one or two long bars of flat or I-beam steel. Square pipe bars are also used. The ends of some runner frames are closed to form a narrow rectangle. The corners are usually reinforced, and braces are placed across the frame in several places. The furrow openers, or runners, are connected below the runner frame.

Accuracy and uniformity of planting depend to a large extent upon the rigidity of the runner frame, for the parts that actually touch and control the flow of seed are mounted on the runner frame.

Feed Shaft (Fig. 104*h*). The feed shaft is mounted on top of the runner frame and is driven by a chain from the rear axle. The speed of the feed shaft may be changed by using the various driving sprockets on the rear axle (*f*). Changing

the speed of the feed shaft is one method by which the distance between kernels in drilled rows may be varied.

Seed Boxes or Hoppers. The seed boxes, or hoppers, are mounted on the runner frame directly above the furrow openers. One seed hopper is provided for each furrow opener. So that they may be easily inverted, they are fastened in place with a latch and a pivot connection. It is necessary to invert the seed hoppers when emptying out unused seed or when changing the seed plate.

Clutch (Fig. 105). The clutch is mounted on the feed shaft; it transmits the driving power from the main axle to the feed shaft. The clutch sprocket is not keyed to the feed shaft but runs freely on it. The clutch must be engaged before the feed shaft is driven by the sprocket.

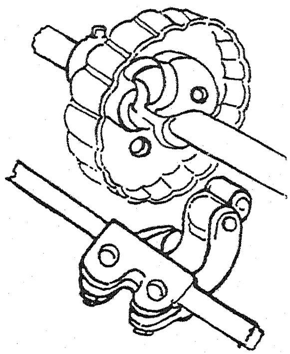


Fig. 105. Corn-planter clutch and clutch stop on check fork.

When drilling corn, the clutch is always engaged and the feed shaft turns steadily. When check-rowing corn, the clutch is engaged before each hill is planted and disengaged after it is planted. The feed shaft, consequently, turns intermittently when check-rowing. The engaging and disengaging of the clutch is accomplished automatically, at exact intervals, by means of the buttons on the check-row wire (Fig. 114).

Seed Plates (Fig. 106). The seed plate is located in the bottom of the hopper. Three types of seed plates are used in corn planters. The edge-drop carries the kernel of corn on edge in the revolving seed plate. The flat-drop carries the kernel flat in the cell of the plate. Both the edge-drop and the flat-drop plates accumulate the necessary number of kernels for a hill one at a time. Each seed cell carries one kernel. As

this cell passes over the outlet to the seed boot (Fig. 107*c*), the kernel drops down to the first valve (*b*). When the desired number of kernels has been collected, the valve is opened and the kernels are dropped to the lower valve (*e*), and thence to the bottom of the seed furrow.

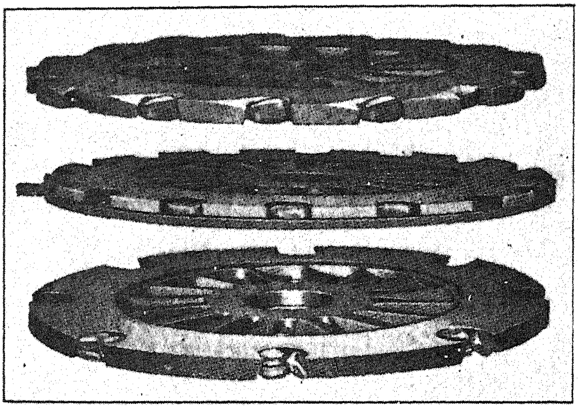


FIG. 106. Three types of seed plates.

The full-hill drop plate has large holes at equal intervals around the edge of the plate. These are large enough to allow several kernels (enough for one hill) to drop through to the valve. This type is not used as generally as the other two, and it does not plant as accurately.

Most corn planters are designed to use any one of the three types of seed plates. The edge-drop seems to be the most satisfactory, provided the seed is graded.

The cells that carry the seeds are located around the outer edge of the seed plate. The bottom of the seed hopper is crowned, or raised, so that all the corn is delivered to the cells of the plate.

As the seed plates revolve, each cell passes over the outlet and drops its kernel. The cut-off, inside the hopper, prevents two kernels from entering the same seed cell and also prevents kernels from lodging or sticking in the cell.

Several sets of plates are furnished with each planter. These are usually marked large, medium, and small. This refers to the size of the cells, and therefore the proper plates should be used for the size of the kernels to be planted.

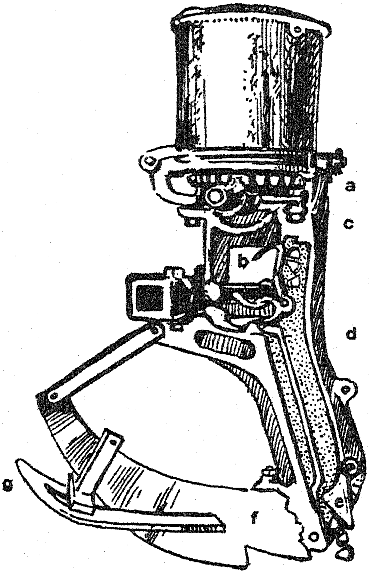


FIG. 107. Interior view of seed boot and valves.

Seed-plate Gear and Pinion (Fig. 108). The seed-plate gear is located directly beneath the seed plate, at the bottom of the hopper. Lugs on the upper side of this gear engage with and drive the seed plate. A small pinion meshes into the underside of the seed-plate gear and transmits the drive to it. The pinion is pinned to the feed shaft. Several holes are drilled through the feed shaft so that the position of the pinion may be changed when the width between the furrow openers is varied.

Variable-drop Devices. When planting corn in check rows, it is desirable to change quickly the number of kernels in the

hills. In some parts of the field four kernels per hill may be desirable, whereas in other parts two or three kernels may be preferred. Check-row planters are usually fitted with a device for accomplishing this change.

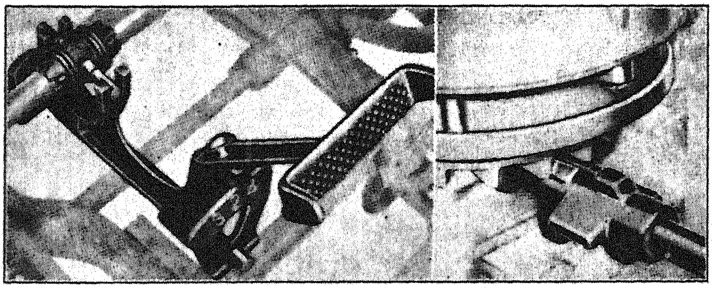


FIG. 108. *Left*—Variable-drop control. *Right*—Seed-plate gear and pinion.

Several different methods are used such as the following:

1. The pinion on the end of the feed shaft may be provided with three sets of teeth. This may be shifted so that two, three, or four kernels may be planted in each hill (Fig. 108).

2. The seed-plate gear may carry three rows of teeth on its underside. Shifting the pinion into the various rows of teeth accomplishes the change in the number of kernels in much the same manner as described above.

3. Another type of variable-drop device controls the distance, or rather the part of a complete revolution, made by the feed shaft for each hill planted. To plant four kernels, the feed shaft makes a complete revolution and four seed cells pass the outlet to the seed boot. To plant three kernels, the feed shaft makes but three-quarters of a revolution; and to plant two kernels, only one-half a revolution.

4. Three gear changes may be provided for the various speeds of the feed shaft. These are carried in an oiltight case (Fig. 109*d*) and are operated by the shifting lever (*e*). The gears are driven by the sprocket (*c*) and the clutch (*b*). The

principle on which they act is similar to that used for tractor or automobile transmissions.

5. Seed plates may be used with a varying number of cells. In a certain type, an 8-cell plate plants 2 kernels per hill; a 12-cell plate plants 3 kernels per hill; a 16-cell plate plants 4 kernels per hill. In each case the seed plate makes a quarter revolution for every hill.

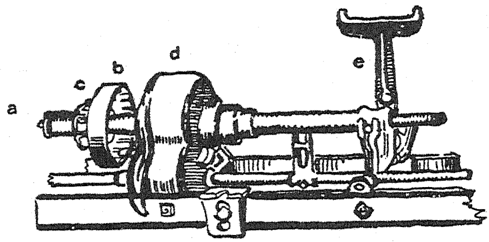


FIG. 109. Clutch and one type of variable-drop mechanism.

In each of the foregoing types of variable drops, the movement of the feed shaft, and consequently the movement of the seed plates, is controlled by the clutch. The feed shaft turns only when the clutch is engaged.

Seed Boot (Fig. 107*d*). The seed boot forms a passageway for the seed from the seed plate down to the bottom of the furrow. It is usually in the form of a large rectangular tube of cast iron. The furrow opener is attached to the lower end of the seed boot.

Valves (Fig. 107). Two valves are enclosed within the seed boot. One of these is located directly below the seed plate (*b*). The other is located near the bottom of the seed boot, close behind the furrow opener (*e*).

When planting corn in hills, the valves are closed until the required number of kernels is accumulated. Then the valves are opened by the action of the buttons on the check wire. The kernels carried above the lower valve drop to the bottom of the furrow. The kernels that were carried above the upper

valve drop down through the seed boot and are caught by the lower valve. Springs return the valves to the closed position. Valve action is so rapid that when the kernels are released from the upper valve the lower valve is closed in time to catch them. The action of the valves and the passage of the kernels of corn through the seed boot are illustrated in Fig. 107.

The lower valve carries the seed for one hill low down, near the bottom of the furrow. When the valve opens, these kernels are dropped together; they all reach the ground at the same time and are not scattered as they would be if only one upper valve were used.

When drilling corn, the valves are not used but are locked open with a latch or foot lever, conveniently placed near the operator's seat. The clutch (Fig. 105) is in constant engagement, and the seed plates revolve steadily (not intermittently as for hill planting). Each kernel drops from its cell in the seed plate, through the outlet, down through the seed boot to the bottom of the furrow.

Checking Head (Fig. 110). The checking fork (*b*) applies the action of the buttons on the check wire to the planter.

(*a*) The check-row wire reaches clear across the field. It is staked securely beyond each end of the field by means of two anchor stakes (Fig. 110*a* and *b*).

(*b*) The wire is entered through the checking head which includes all the parts of the planter which guide or control the wire. Roller guides are used to hold the wire in the checking head and guide it to the checking fork.

(*c*) As the planter is driven across the fields, the wire slides through the checking fork. One button after another strikes the checking fork and bends it down, as shown in Fig. 110*B*.

(*d*) The action of the checking fork opens the valves and engages the clutch. When the button on the wire has bent down the checking fork to an extreme position, the button slips past and the checking fork returns to its original up-

right position. The return of the checking fork allows the valves to close and the clutch to disengage.

When the button on the wire strikes the checking fork and bends it backwards, the following events take place simultaneously:

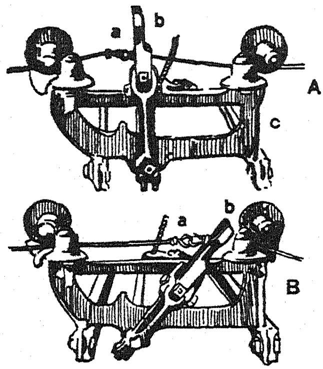


FIG. 110. Checking head.

1. Kernels above the lower valve drop to the ground.
2. Kernels above the upper valve drop to the lower valve.
3. The clutch engages, causing the seed plates to turn and accumulate the kernels for another hill, above the upper valve.

For drilling corn, the checking wire is not used. The checking fork is held down, the valves are always open, the clutch is constantly engaged, and the seed plates turn steadily.

Furrow Openers

The furrow openers are attached to the lower end of the seed boot. Their function is to open a furrow of uniform depth into which the seed may be dropped. The depth of the furrow and the depth of planting are regulated by means of a pressure lever and spring.

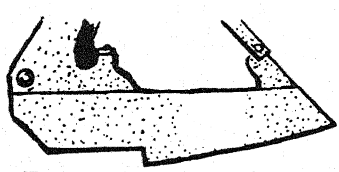


FIG. 111. Stub-runner furrow opener.

There are four types of furrow openers in common use: the curved-runner (Fig. 107), the stub-runner (Fig. 111), and the single- and double-disk openers.

The description of disk furrow openers in the chapter on drills applies equally well to the corn planter. The curved-runner or shoe furrow opener

is also similar to that of the shoe furrow opener used on drills. The stub-runner opener is designed for use on ground that has a great many stones or a large amount of trash. The stub-shaped front of the runner gets under such obstructions and pushes them aside.

Gauge shoes (Fig. 107) are frequently used with the furrow openers. They serve to maintain a uniform depth in loose or very mellow soils.

Covering Devices. It is usual for a set of coverers to be furnished with the planter, but in many soils it is not necessary to use the coverers. The main wheels of the planter have a tendency to gather the soil and tamp or pack it lightly over the seed.

Fertilizer Attachment (Fig. 112). Fertilizer attachments may be mounted on any of the modern corn planters.

A sprocket on the main axle drives the feed shaft of the fertilizer attachment. The speed of the feed shaft may be varied by changing the sprockets, thus varying the rate of flow of the fertilizer. The amount of fertilizer distributed may also be changed by an adjustable gate provided on each hopper, which regulates the size of the fertilizer outlet.

The fertilizer feed is of the finger type described in the chapter on drills.

A fertilizer tube leads from the bottom of the hopper to the rear furrow opener. A valve, in the lower end of this tube, is operated by the check fork, in unison with the valves of the seed boot. This action drops the fertilizer in the soil in the proper position with relation to the hill of corn.

When drilling corn, the fertilizer valve is locked open, in the same manner as the valves in the seed boot, thus drilling the fertilizer into the row.

The outlet of the fertilizer boat on modern planters is divided. This places a band of fertilizer at each side of the corn. For hill planting, the bands are concentrated near the hills, while for drill planting the bands are continuous.

Markers. The function of the marker is to make a distinct line or mark in the soil as a guide to the operator. Figure 114 shows the position of the marker when the planter is in operation. The operator keeps the pole of the planter directly over the line made by the marker on the previous trip across the

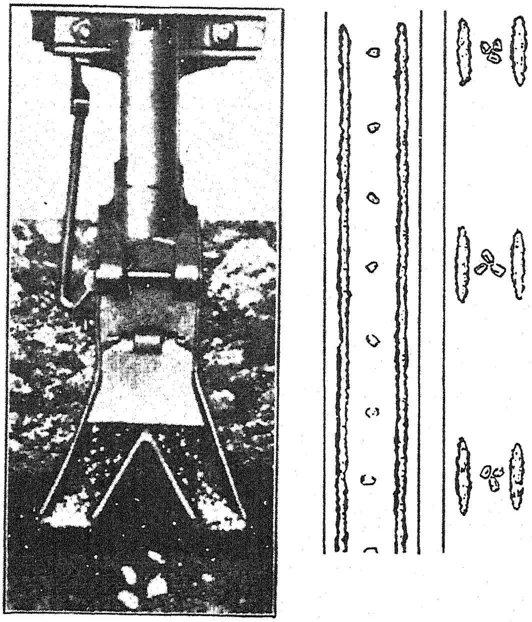


FIG. 112. Fertilizer attachment with divided boot. Fertilizer placement for drilling or hilling.

field. Markers are adjustable to suit the width between the furrow openers. This adjustment must be changed if the distance between the furrow openers is varied. The horizontal distance from the center of the planter to the line made by the marker should be twice the distance between the furrow openers for two-row planters.

At each end of the field when the planter is turned for the return trip, it is necessary to swing the marker from one side of the planter to the other, in order that the mark may be

made in the unplanted side of the field. A means for reversing the marker is usually provided. In some planters double markers are used so that reversing the marker is not necessary.

Check-row Wire and Reel. A section of check-row wire with the buttons is shown in Fig. 114. Wire is usually furnished with the planter in 80-rod lengths. More or less must be used according to the length of the field. Special connecting links are placed every few rods, so that the wire may be disconnected easily and the desired length obtained.

The spacing of the buttons on the wire determines the

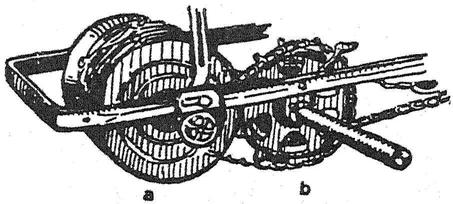


FIG. 113. Reel for check-row wire.

distance between the hills in the row. Wire suitable for any desired distance of planting, from 30 to 48 inches, may be obtained.

The wire when not in use is carried on the wire reel (Fig. 113), which holds 160 rods. The reel is used only for winding and unwinding the wire. It is driven by a sprocket on the axle (*b*), or by means of a frictional contact with the main wheel. A tension-regulating device is provided so that the wire may be kept tight, and a guide is used to distribute the wire evenly over the reel.

JOB 10

TO TEST THE ACCURACY OF A CHECK-ROW PLANTER

Procedure

1. Jack up the planter securely, so that both wheels and the furrow openers are off the floor. Have the runner frame level.
2. Put "small" seed plates in place under the hopper.

3. Fill each hopper about half full of seed corn.
4. Set the variable-drop lever to drop three kernels per hill.
5. Set the foot-trip lever so that the valves in the seed boot are closed.
6. Revolve the driving wheel of the planter at about the same speed at which it would turn in the field.
7. While the wheel is revolving steadily, have some one trip the check fork. (It should be tripped quickly and allowed to return promptly to the closed position.)
8. Make fifteen or twenty drops in this manner, and count the number of kernels dropped each time.
9. Set the variable-drop lever for two kernels per hill and make the same test.
10. Set the variable-drop lever for four kernels per hill and make the same test.
11. Make the same tests with "large" seed plates, and then with "medium" seed plates, in place in the seed hopper. Which set of plates gives the most accurate planting?
12. Select seed plates best adapted to the corn to be planted. To plant accurately the hybrid seed corn, now commonly used, requires careful seed-plate selection. The kernels of the different hybrids, though valuable and highly productive, vary greatly in shape and size. For accurate planting the seed should first be graded with a seed-corn grader. Then various plates should be tested, as described above, and the set giving best results should be selected. Implement dealers have a seed-plate testing device which facilitates accurate selection. Manufacturers have such a great variety of seed plates available that any hybrid may be accurately planted.
13. Determine the adjustments necessary to change from check-row planting to drilling.
14. Adjust the planter for drilling. Determine how the drilling distance may be varied. The instruction book, furnished with the planter, gives the sprocket combinations, variable-drop settings, and seed plates for different distances between

kernels in the row. This distance between kernels is called *drilling distance.* Drilling distance is lessened by:

(*a*) Increasing the speed of the feed shaft, with relation to forward travel, by changing the sprocket combination between the main axle and feed shaft and by the variable-drop mechanism.

(*b*) Selecting a seed plate with more cells. Some seed plates, like the one for broom corn, have sixty-four cells and will plant sixty-four kernels in making one revolution.

(*c*) Selecting a seed plate with larger cells. Some seed plates have cells which carry four kernels each.

(*d*) Using low main wheels instead of high wheels.

JOB 11

TO REPAIR A CHECK-ROW CORN PLANTER

Procedure

1. Get the owner's or operator's report on the condition of the planter; field troubles; worn, broken, or missing parts; faulty adjustments; the name of the manufacturer; year of purchase. (Try to secure the repair catalog and instruction book which was furnished with the planter.)

2. Test and inspect all parts. Jack up the planter so that both main wheels clear the floor. Have the runner frame and hoppers level. Turn the drive wheel and watch the action of all moving parts with the planter set for drilling. Test also for check-row planting, tripping the check forks by hand. Note particularly the condition and action of the clutch parts and clutch stop on the check shaft (Fig. 105).

3. List repair operations needed.

4. Order repair parts.

5. Clean the seed hoppers. Remove the seed plates and wash off any accumulation of dirt on the seed-plate driving parts. See that the seed-plate gear and feed-shaft pinion mesh properly and are not loose.

6. Clean the fertilizer hopper. If fertilizer remains in the

hopper, the finger-feed wheel will become stuck. If the fertilizer has hardened, it may be dissolved with hot water or kerosene. See that the cam which regulates the fertilizer feed works freely. Test the fertilizer driving mechanism. When repairs are completed and all fertilizer parts are clean, the parts should be painted. Otherwise, the reaction of the fertilizer will cause rusting and pitting of the metal.

7. Revolve the feed shaft and test its bearings. Replace them if necessary. Loose or worn bearings may cause the pinion on the feed shaft to slip out of mesh with the seed-plate gear. This would cause irregular planting and possible "skips" in the field.

8. Examine and repair the clutch. Accuracy in planting, especially check-row planting, depends largely upon perfect action of the clutch. Each time a wire button strikes the check fork the clutch engages and drives the feed shaft through one complete revolution, after which the clutch must disengage. The action is rapid. Clutch rollers and springs must be in good condition to function well.

9. Clean the variable-drop mechanism. Examine the parts carefully and test the action of each part. Replace worn parts. Lubricate all moving parts of this mechanism thoroughly.

10. Clean and repair valves. The valves in the seed boot and the fertilizer boot should be carefully tested. Slow action of these parts causes hills to be scattered along the row, a condition which makes cross cultivation difficult or impossible. Replace weak valve springs and lubricate the valve pivot shafts.

11. Repair the furrow openers. All types of furrow openers should be kept sharp. The bearings of disk furrow openers should be cleaned and lubricated or replaced if necessary.

12. Test and repair check-row mechanism. Test the action of the check shaft, check fork, wire retaining rollers, wire release latches, and reel connections for the wire. Rust or binding in any of these parts will cause trouble in the field.

13. Remove all chains and soak them in a pail of kerosene,

then in oil. The kerosene loosens and removes the dirt and hardened grease, and the oil prevents rusting. Replace the chains on their sprockets and adjust them as outlined on p. 339.

14. Paint and lubricate. Paint all parts as required. Usually both the inside and outside of the seed and fertilizer hoppers require painting. As a final precaution, before storing the planter, lubricate all working parts including the following:

(*a*) Main-axle bearings.
(*b*) Feed-shaft bearings.
(*c*) Clutch parts.
(*d*) Variable-drop device.
(*e*) Drive-wheel bearing.
(*f*) Disk-opener bearing.
(*e*) Bearing of disk marker.
(*f*) Valves and check forks.
(*g*) Fertilizer feed shaft and clutch.
(*h*) Fertilizer attachment valves.
(*k*) Rollers on checking head.
(*l*) Bearings of reel hangers.

Operating a Check-row Corn Planter

1. Select the seed plates. (See p. 148.)

2. Adjust the hitch. The eveners are carried on top of the pole, which is in the center of the corn planter. Consequently, no side draft will exist and the horizontal hitch will present no problem. The adjustment of the height of the pole on horse-drawn planters, or the height of the vertical hitch on tractor planters is important if the corn is to be planted in check rows.

If the front of the pole is carried too low, the hills will be dropped a few inches behind the button on the check wire. Raising the pole will throw the heel of the furrow openers forward and cause the kernels to be carried a little further before being dropped.

The kernels must be dropped at points almost directly below the buttons on the check wire. If, on the first trip across the field, the kernels for the hill are dropped 3 inches behind the button, then on the return trip they will also be dropped 3 inches behind the button; but, as the planter is moving in the opposite direction, this means that the hills of the first

two rows will be several inches out of check with those of the next two rows. This will occur throughout the entire field. The height of the hitch should be such that the kernels are dropped not more than $1\frac{1}{2}$ inches behind the button on the check wire. The wire "travels" or stretches in the direction the planter moves. If the amount of this travel is 3 inches (in each direction), and if the hills are planted $1\frac{1}{2}$ inches behind the buttons, the hills should be in exact check. A special adjustment is provided which permits tilting the seed boots to place the hills in correct relation to the buttons.

To make sure that the rows are in line crosswise, it is a good plan to dig up a few rows across the field and see if the hills are in line.

3. Adjust the distance between rows to the desired width. Corn planters are usually assembled with the furrow openers spaced 42 inches apart. If it is desired to change this width, the following adjustments must be made:

(*a*) Width between furrow openers.
(*b*) Width between drive wheels.
(*c*) Spacing between buttons on the check wire (if corn is planted in check rows). This would require another roll of wire, with buttons spaced the width desired.

The three adjustments just mentioned should all be spaced equally. In addition to these, the pinions on the feed shaft must be moved, and the marker adjusted. The distance from the center of the planter to the line made by the marker should always be twice the distance between the rows. The operator drives so as to keep the pole directly over the last marker line.

4. Stake out the check wire and begin planting.

(*a*) Place roll of wire in the reel holder.
(*b*) Set on anchor stake back from the edge of the field, as shown in Fig. 114. (If stakes cannot be set beyond the edges of the field, headlands must be left.)
(*c*) Attach wire from the reel to this stake.

(*d*) Drive straight across the field, allowing the wire to unreel. Keep close to the edge of the field. Keep enough tension on the reel to make the wire tight.

(*e*) When the opposite end of the field is reached, disconnect the wire and remove the reel from the planter.

(*f*) Turn the planter around and get it in position to plant the first two rows (position 2 in Fig. 114).

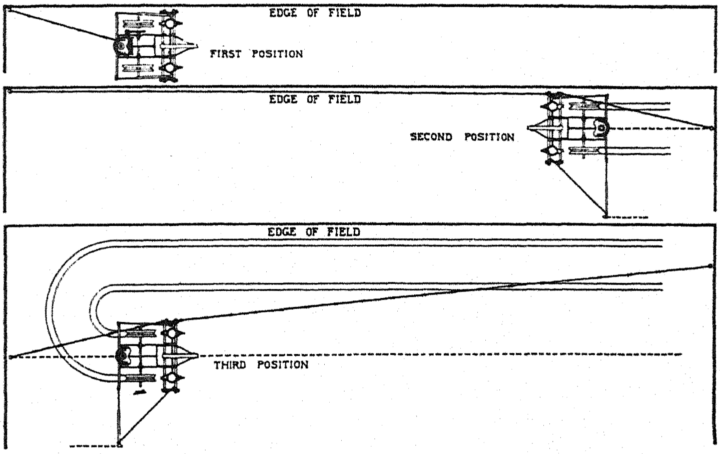


FIG. 114. Laying out check wire.

(*g*) Anchor the second stake directly behind the center of the planter, as shown in Fig. 114*b*.

Gauges, which are graduated in pounds and which measure the tension or "pull" on the wire when it is staked down, may be obtained for the anchor stakes. With these gauges the wire may be pulled to the same tension each time an anchor stake is set. Pull the wire to 60 pounds' tension (recommended tension) and attach it to the stake.

(*h*) Put the marker in position. Fill the hoppers. Lower the furrow openers. Put the wire through the check head, and plant across the field.

(*i*) Just before reaching the first anchor stake, release the wire from the check head. Raise the marker.

To make sure the wire is released at the same point each time, tie a cloth to the fifth button from each anchor.

(*j*) Turn the planter around so that the pole, or center of the tractor, is centered on the marker line.

(*k*) Reset the stake behind the center of the planter. This must be done at each end of the field, each time, after the planter has been turned around.

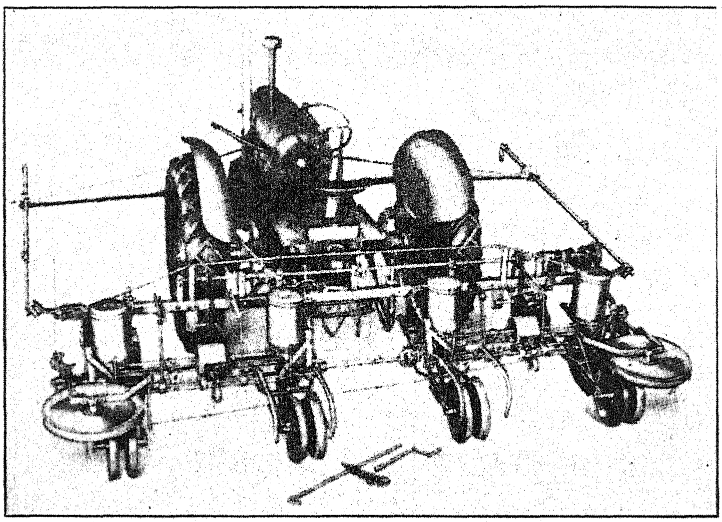


FIG. 115. Four-row tractor planter.

5. Adjust the depth of planting. The depth of planting is controlled by the lever which raises or lowers the furrow openers. Penetration is secured by means of the pressure of a heavy spring which acts when the furrow openers are lowered.

6. Set the variable-drop device to plant the desired number of kernels per hill.

7. Set the rate of flow of fertilizer. This may be regulated

by changing the size of the opening between the hopper and the delivery spout or by changing the sprocket which drives the fertilizer shaft.

8. Plant the main body of the field.

9. If headlands have been left, remove the wire and plant across the headlands. This is done without the use of the check wire. A foot pedal is provided for the purpose of operating the checking device. As the planter is driven across the field, the foot pedal is used to drop hills in line with the rows, which usually are clearly visible.

10. Reel up the wire. Unhook the wire from the anchor stakes and thread it through the guides (sheave guides are used with tractors); then attach it to the reel. Engage the reel driving clutch and drive slowly enough to wind the wire uniformly and at proper tension. Some anchor stakes are designed to be used for guiding the wire evenly on to the reel.

Types, Sizes, and Special Equipment

The various sizes of tractor planters include a two-row, horse-drawn planter; a two-row, and a four-row, tractor-trailed type; and a two-row, and a four-row, tractor-mounted (integral) type.

Hill-drop Attachment. To plant in hills, without using a check wire, a cam or arm on the feed shaft must operate the check shaft and valves at regular intervals. By using a double arm (Fig. 116) the distance between hills is halved.

With this attachment either the full hill-drop plate or the cumulative plate may be used.

Tongue Truck. This attachment is desirable on horse-drawn planters. It supports the planter, steadies it, and gives more accurate and uniform planting, and eliminates neck weight on the horses as well.

Depth Gauges. Gauge shoes (Fig. 107) may be attached to the runner-type furrow openers, and gauge wheels may be used with all types of openers.

Pea and Bean Attachment (Fig. 116). With this attachment peas or beans may be planted in the hill with the corn, or the two crops may be drilled through separate seed tubes. Some planters are furnished with a divided hopper for planting two crops at once.

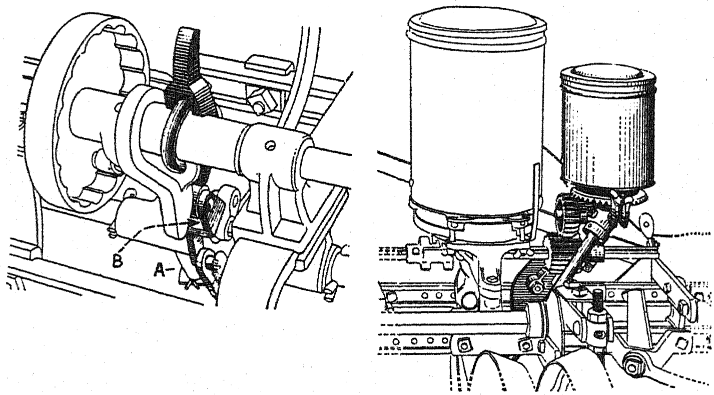


FIG. 116. Hill-drop attachment. Pea and bean planting attachment.

Furrowing Attachments. When a ridge is desired along each side of the seed row, a disk or blade-furrowing attachment may be obtained. This method of planting is practiced in regions of limited rainfall. Some of the soil in the ridge can be returned to the row when the young plants are cultivated, thus facilitating the killing of weeds in the row.

TRANSPLANTERS

Transplanters are used to set the plants, to water them, and to firm the soil over the roots. They may also be equipped with fertilizer attachments, which give accurate control of the amount and position of the fertilizer placed near the roots of the plant.

Plants such as cabbage, tomato, tobacco, strawberry, sweet potato, celery, as well as nursery stock, shrubs, bulbs, and many others, are reset by transplanting machines.

Types and Sizes. A small, portable plant setter is available and is used by some growers, especially for replanting "misses." The larger of the two cylinders carries water. The tapered end is pushed into the ground by foot pressure on the step to open a seed hole; the plant is dropped through the small cylinder and the soil is firmed by rocking the unit to one side.

The automatic transplanter has a series of pockets or plant-holding cups which set the plants in the soil at the rear of the furrow opener. The operator, sitting in front of the planting wheels, places the plants in each pocket. Machines of this type are used chiefly in sections where a large acreage of a single crop is grown.

In the manual-setting type, the operator actually sets the plants in the soil. Machines of this type are more widely used than the automatic type.

Either the automatic or manual-setting designs may be secured in single- or multiple-row units. In these units, men are usually required to set each row of plants; hence machines of more than two-row capacity are not often used. The various types include horse-drawn and tractor-drawn models and tractor-mounted models; and, for special crops, self-propelled transplanters are available. By using a multiple hitch two or three single-row machines may be drawn by one tractor.

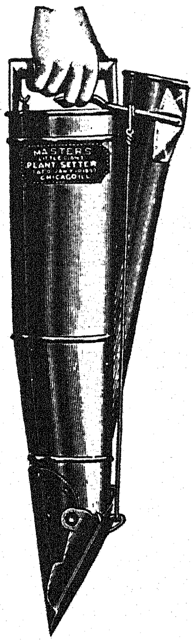


FIG. 117. Hand plant setter.

Construction and Action

Main Wheels. The main wheels must support the weight of the machine, including the weight of the driver, two planter setters, 40 to 50 gallons of water, and perhaps 150 pounds of

fertilizer and plants; the total weight may approach 2000 pounds. To support this weight, especially on a mellow seed bed, wide-tired wheels are needed. Five-inch or 6-inch rims are desirable. Pneumatic tires 7.5 by 24 inches may be secured.

Transmission of Power. Power is transmitted from one of the main wheels by gears or chains to the cam operating the water valve and to the fertilizer attachment. The power re-

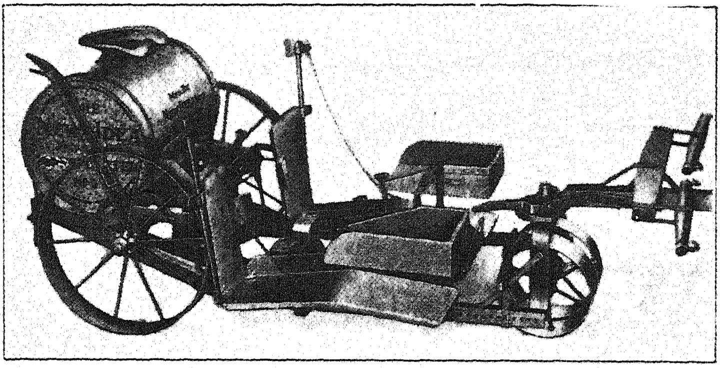


FIG. 118. Manual-setting transplanter.

quired at these two points is not great and a single drive wheel is sufficient.

In some planters, the water-valve cam also operates a plant-setting gauge (Fig. 120).

Water Valve. Watering the newly set plants is essential. Even with a watering device, growers try to transplant when the ground has ample moisture. A water line extends from the main tank to a valve situated between the two blades of the furrow opener.

The water valve is opened once for every plant set, by the cam shown in the diagram. By changing the sprockets or gears driving the cam, various intervals, or distances, may be obtained between openings. For further changes in distance between plants, a one-roller cam or a four-roller cam may be

used. The amount of water per plant is regulated by a separate valve in the line. The opening of the water valve with its attendant clicking sound is the signal to the planter to place the plant.

Setting the Plant. The plant setter places the plant and supports it by hand until the water has been discharged on the

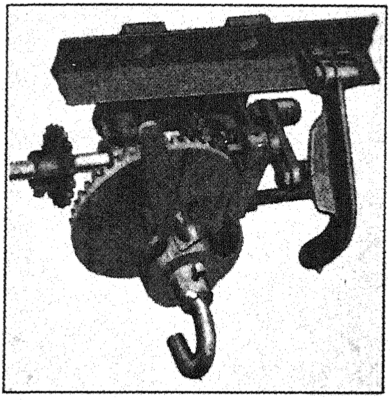


FIG. 119. Mechanism for operating water valve and planting signal.

roots and the soil is firmed above it by the press plates or press wheels. Some designs have a plant-setting gauge at the rear of the furrow opener (Fig. 120). The plant is held against this until the gauge has been pushed fully to the rear, at which time the operator releases the plant. The water valve and gauge are timed so that the plant has been watered and the soil is closing on the roots when the operator releases the plant.

The distance between plants in the row may be varied from 11 to 74 inches. With special equipment, closer planting is possible. The distance between rows may be 26 inches or more when the regular axle is used. But narrower widths are possible if a special, long axle is used which enables the planter to straddle two rows.

Fertilizer Attachment. Front mounting of the attachment places the fertilizer before the plant furrow is opened, thus preventing actual contact between fertilizer and plants. Delivery of fertilizer may be from two spouts or three; the outlet from each is controlled by a separate valve. The center spout delivers a small amount in front of the main furrow opener; the

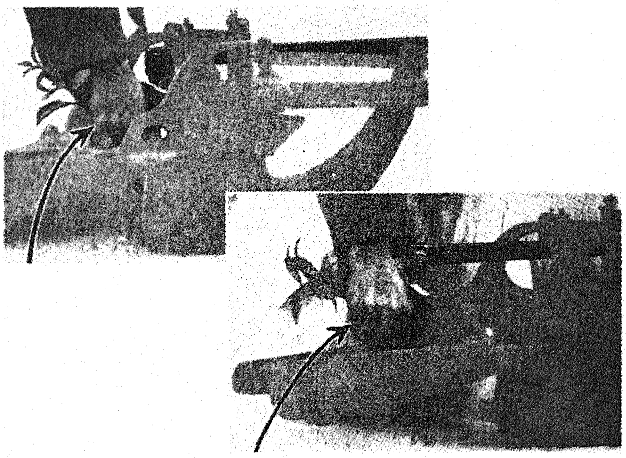


FIG. 120. Plant-setting gauge.

other two deliver in bands. Most machines distribute the fertilizer in continuous bands about 5 inches from the row; some are designed to give a "broken band" such as shown in (Fig. 112). This method is economical and efficient, especially when plants are set at a considerable distance apart.

Press Wheels. Instead of the press plates, adjustable press wheels with scrapers are furnished when desired. They are best for use in heavy, cloddy, or stony ground.

Forecarriage. This is commonly furnished with horse-drawn units but is not essential for tractor-drawn planters. Single- or double-wheel trucks which caster when turning at the ends, but are fixed when traveling straight, may be secured.

Foot Trip. This device is used where fields have been previously marked for check-row planting. Either of the two plant setters may trip the water valve and set his plant at the intersections of the marks.

Check-row Attachment. Available for most transplanters, this attachment accomplishes check-row planting by the use of a check wire and a check shaft, the same as the corn planter. The check fork operates the water valve and the plant-setting indicator simultaneously.

Potato Planting. Usually potato planting is accomplished by adding the furrow opener and hopper illustrated. A valve in the hopper driven by a connection to the water valve, drops the seed automatically.

Lump Scraper. This attachment cleans stones and clods from the path of the main furrow opener and makes possible more accurate and uniform planting.

Nursery Attachment. A special furrow opener for setting nursery stock is available. It is larger and wider than the standard type. This will permit planting to a depth of 8 inches.

CHAPTER V

CULTIVATORS

Row-crop cultivators are used for tillage after the crop has grown to such an extent that the harrow or weeder cannot be used. The chief function of a cultivator is to kill weeds, but it also stirs and aerates the soil, mulches the surface, and makes the plant food more easily available. Cultivators must be accurately controlled, adjusted, and fitted with proper cultivating tools. The cultivator stirs the soil very near the roots of the growing crop. If it is set too deep, or if it is not carefully guided, the growth of the crop may be retarded and the yield reduced. This implement is used chiefly for cultivating crops grown in rows, such as corn, cotton, potatoes, etc.

Field cultivators (Fig. 144) are used to work the surface of the soil without inverting it. They are often used instead of the plow for seed bed preparation. Their working members are not spaced to permit plants to pass between, but rather, they work all the ground as a harrow does.

Types and Sizes

Cultivators are manufactured in a great many different styles and sizes. With the exception of the plow, no other single class of farm machines has so great a diversity of types. Many factors affect the problem of properly selecting a cultivator of suitable size and construction. The kind of crop, the soil conditions, the acreage, the power available, and the amount of rainfall are some of the important factors to be considered in the choice of a cultivator. Cultivation given the early growth is different from that required later. Because of all these factors, a large number of types and sizes are available.

The first time a crop is cultivated, the cultivating tools are

set to penetrate more deeply than in later cultivations when the root system is better developed. Special tools, called *surface blades*, may be secured for late cultivations. Certain crops require hilling up; for this purpose disk cultivators or special hilling shovels are often used. Cultivation is necessary in all types and sizes of fields from the smallest garden to the largest field of corn or cotton. This wide variety of conditions has caused the development of a great number of sizes and types of cultivators, and many attachments and tools for them.

Wheel Hoes (Fig. 121). Wheel hoes are operated by hand. They are furnished with single or double wheels. The regular

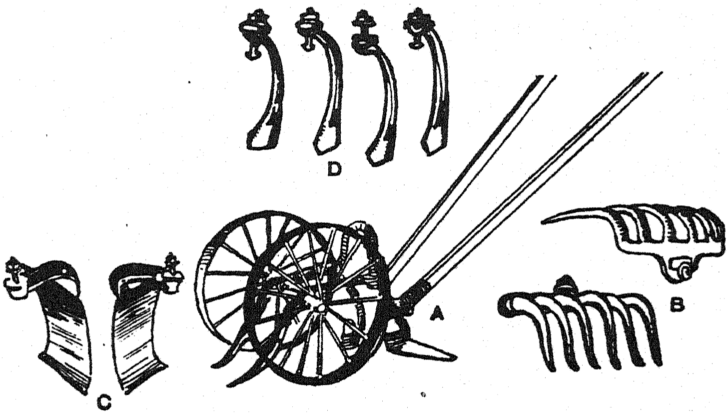


Fig. 121. Wheel hoe and equipment.

equipment includes (*A*) a pair of hoes, (*B*) one pair of rakes, (*C*) plows, (*D*) four cultivator teeth.

Repairing the wheel hoe usually requires the following operations:

1. Take off the wheels. Clean and oil the wheel bearings. If they are badly worn, new bearing bolts (axles) or bushings should be put in.
2. Sharpen all the cultivating tools on the grindstone.

Grind them so that they retain their original shape or bevel. These tools may be sharpened with a file if a grindstone is not at hand.

3. Tighten all bolts, especially the handle bolts and braces.
4. Paint all parts, except the cultivating tools which should be coated with heavy grease.

The best results will be obtained in operating a wheel hoe if the following suggestions are followed:

1. Select the proper tools for the type of work to be done.
2. Keep the wheels well lubricated. See that the bolts which attach the tool holder to the handles and arch are kept tight. Otherwise the tools will not be held rigidly and poor work will result. Each tool has a small, square lug that fits into a slot in the tool holder. The nuts securing the tool must be kept tight to hold the tool in proper alignment.
3. Depth of penetration is controlled by the amount of downward pressure put on the handles. Wheel hoes are pushed forward in strokes of a few feet at a time. More accurate work can be done in this manner than by pushing the wheel hoe steadily forward.
4. The leaf guards should be adjusted so that they turn the leaves or vines away from the wheels, thus preventing their being damaged.

Work can be done much faster with this type of tool than with the hand hoe. Various attachments make it useful for many jobs.

One-horse Cultivators (Figs. 122 and 123). The number of shovels used varies from five to nine. Double-edged shovels are usually furnished so that the shovel may be reversed to secure a new cutting edge. The shovels are attached to the shank with one bolt. A lever is provided for adjusting the width of the cultivator.

The singletree is connected to the draft hook (Fig. 122*e*).

This may be adjusted vertically by means of the holes in the draft iron.

A gauge wheel is supplied to aid in controlling the depth and for transporting the cultivator to and from the field.

A wide variety of cultivating tools may be obtained for use with these cultivators.

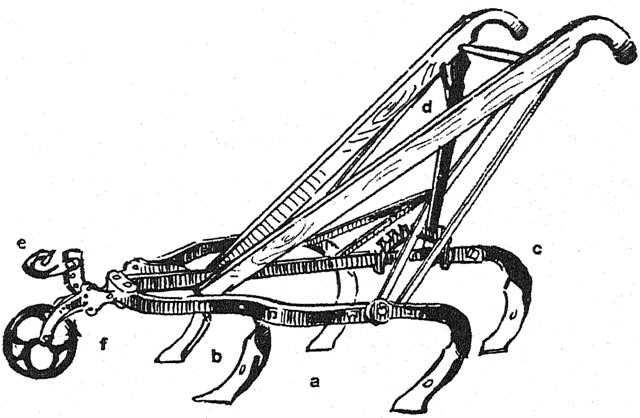


FIG. 122. One-horse cultivator with reversible shovels.

One-horse cultivators are drawn between the rows, not astraddle of the row.

The design shown in Fig. 123 is furnished with adjusting rods and linkage with which the shovels can be arranged in a straight line, or in an A shape or in a V shape, or with all teeth on the right or all on the left side of the beam. With the V placement the cultivator is used as a side harrow for cultivating the sides of ridges. With the center tooth removed, it may be used as a straddle row cultivator.

OPERATING A ONE-HORSE CULTIVATOR

These cultivators are drawn between the rows by one horse traveling down the center of the space between adjoining rows.

The hitch may be adjusted up or down in the draft iron.

It should be placed low if shallow cultivation is desired and high if deep cultivation is desired.

No horizontal- or lateral-hitch adjustment is necessary since the center of resistance is directly in line with the center of power.

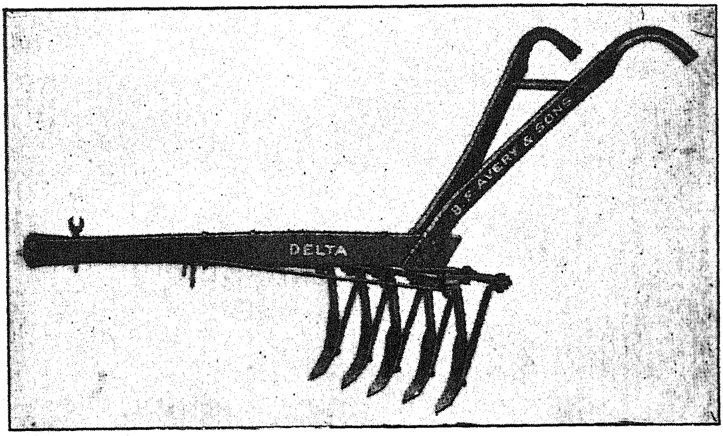


FIG. 123. One-horse cultivator, with teeth arranged for working one side of ridged rows.

The width of the cultivator is adjusted by means of the lever. It is usually set wide enough to cultivate thoroughly all the space between the rows. (See Fig. 122.)

The penetration, or depth of cultivation, is dependent upon the sharpness and angle of the shovels, the position of the hitch, and the condition of the soil.

If the soil is wet and sticky, it will not scour off the shovels, making good cultivating impossible.

Repairing a one-horse cultivator usually requires the following operations:

1. Remove the gauge wheel. Clean and oil the bearing. Put in a new bearing bolt bushing or an axle if necessary.
2. Remove and sharpen the shovels on the grindstone.

These are ground on the back side. Reverse double-point shovels.

3. Tighten all brace rods, so that the cultivator is rigid.

4. Operate the adjusting lever. Oil the lever detent or plunger and see that the lever functions properly.

5. Cover the shovels with a coating of oil or grease.

6. Paint all parts of the cultivator.

Straddle-row Cultivators

One-row and two-row straddle cultivators are the common sizes for horse-drawn units. Tractor cultivators are built in one-, two-, three-, and four-row sizes.

This cultivator straddles the rows, that is, the cultivating tools work on each side of the row.

Either walking or riding cultivators may be obtained. Some combination types are made so that the operator may either walk or ride.

Construction of Walking Cultivators

Walking cultivators are made only in the one-row size. They are cheaper than riding cultivators, and are preferred by some farmers, especially for use when the plants are young and small.

Wheels (Fig. 124*a*). Two steel wheels are used. The hub has a removable wheel box similar to that used in plow wheels. The wheel is retained on the axle by means of a pin and an adjustable washer. The hub cap is used as a grease cup. The distance between the wheels may be changed so that the cultivator may be used for wide or narrow rows.

Gangs (Fig. 124*c*). The gangs or rigs carry the shovels or cultivating tools. They are made of flat or channel steel or of round pipe. The front ends of the gangs are connected to the arch (*d*) by an adjustable coupling. These couplings are provided with cone-shaped bearings. A worn bearing may be taken up by tightening the nut at the top of the coupling.

The gang couplings allow the gangs to swivel or swing in and out easily. Thus the operator, by manipulating the handles, can cultivate the rows very accurately.

Arch (Fig. 124*d*). The front end of the gangs connects to the arch, the width of which is adjustable. The upper ends of the arch arms may be slipped in and out of the bracket

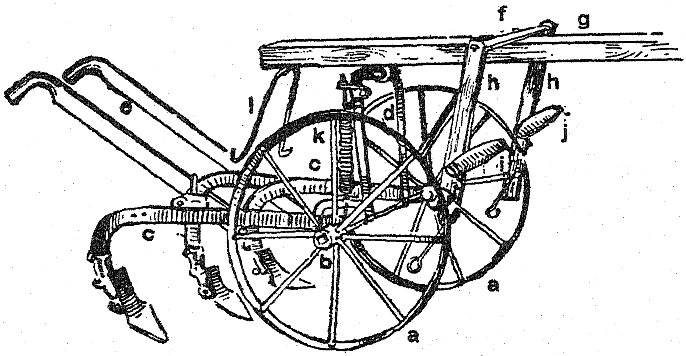


Fig. 124. Two-horse walking cultivator (straddle row).

mounted under the pole. This adjusts the cultivator for wide or narrow rows.

The lower ends of the arch in walking cultivators are used as axles of the wheels.

Eveners (Fig. 124*j*). Two-horse eveners are supplied with walking cultivators. The evener is made of steel and is fastened to the pole with a clevis. A steel pendant is hooked over each end of the evener bar and hangs downward. The lower ends of the pendant are connected by links to an adjustable draft iron, which is located at the point where the gangs connect to the arch. The height of the singletrees is adjustable by means of the series of holes in the pendant. If the singletrees are placed high, the pull is downward and better penetration is thus secured in hard ground. A low hitch has a tendency to pull upward, thus lessening the penetration.

Lifting Springs (Fig. 124*k*). The lifting springs aid the operator in lifting the gangs out of the ground. The tension of these springs should be adjusted so that the gangs balance when in the raised position, that is, so that the tension of the springs alone is enough to hold up the gangs. The lifting springs are connected to the gangs in such a way that they exert little or no lifting power when the gangs are in the ground; it is only after the operator has started to lift them that the action of the springs becomes effective.

Hang-up Hooks (Fig. 124*l*). The hang-up hooks support the gangs when they are in the raised position. They should always be kept in this position when the cultivator is not in use.

Pole (Fig. 124*g*). The pole is made of wood. The rear end of the pole is bolted to the arch and is supported by braces from the lower end of the arch.

Handles (Fig. 124*e*). Steering or guiding the gangs is accomplished by means of the handles. As each gang is independent of the other, two handles are provided. The handles are usually connected to the gangs by an adjustable casting so that they may be raised, lowered, or turned in or out, as desired by the operator.

Attachment of Shovels. The cultivating shovels, or teeth, are attached to the gangs by means of the following parts:

(*a*) *Standards.* The ends of the gang beams are turned downward and are almost vertical in the lighter walking cultivator shown in Fig. 125. These parts of the gangs serve as standards to carry the shovels. Separate standards, providing individual adjustment, are used on riding cultivators and tractor cultivators. (See Fig. 126.)

(*b*) *Sleeve or Shank.* This is fastened to the standard with one bolt or rivet which passes through an adjusting slot in the sleeve and through a hole in the shank. The sleeve is also held in place on the shank by means of a

wooden pin. This pin passes through holes in the sleeve and binds against the back of the shank. This is the *break-pin* type of construction. When the shovel strikes a rock or obstruction, the wooden pin breaks. This allows the sleeve to pivot on the bolt, and the shovel passes over the obstruction. The shovel must then be returned to its original position

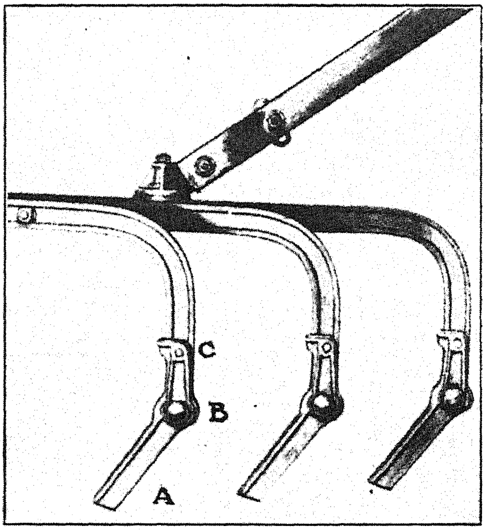


FIG. 125. Beams and shank. *A*—Shank or sleeve. *B*—Pivot (bolt or rivet). *C*—Beam, fitted with wooden break pin.

and secured with a new wooden pin. Some cultivator shovels are provided with *spring trips* (Fig. 126). When the shovel strikes an obstruction, the jar or blow compresses a spring and the shovel bends backward and passes over the obstruction, as shown. It then automatically springs back to normal position. This construction eliminates the necessity of the operator's frequently cutting and fitting wooden break pins. The tension of the spring in the tripping device is adjustable, and the trip must be oiled to prevent the joints from rusting.

(*c*) *Shovel.* The back of the tooth or shovel is fitted with a slotted clamp. This slips over the round surface of the sleeve and is drawn tight by means of the clamp bolt.

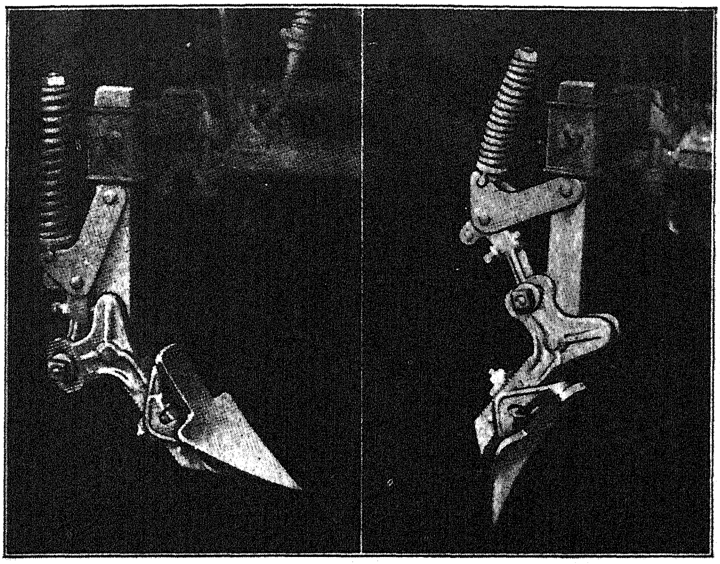


FIG. 126. Shovels with spring trip. Separate standard for vertical adjustment and cross head for lateral adjustment.

Types of Shovels. Many different types of shovels are used. The group at *A* (Fig. 127) shows three double-pointed (reversible) shovels, varying in width from 1 to 3½ inches, approximately 9 inches long. These are suited for deep cultivation. The spearhead shovels (*B*) 4½ to 7 inches wide are used largely for cultivating corn, often furnished with detachable points. Straight shovels (*C*) 3½ to 6 inches wide are for general work. They shed the soil toward both sides. Twisted shovels (*D*) shed most of the soil off the high side. Half sweeps (*E*) are placed next to the plant row and give shallow cultivation, slicing or shaving off the weeds just below the surface. Full sweeps (*F*) are placed toward the centers of the row and

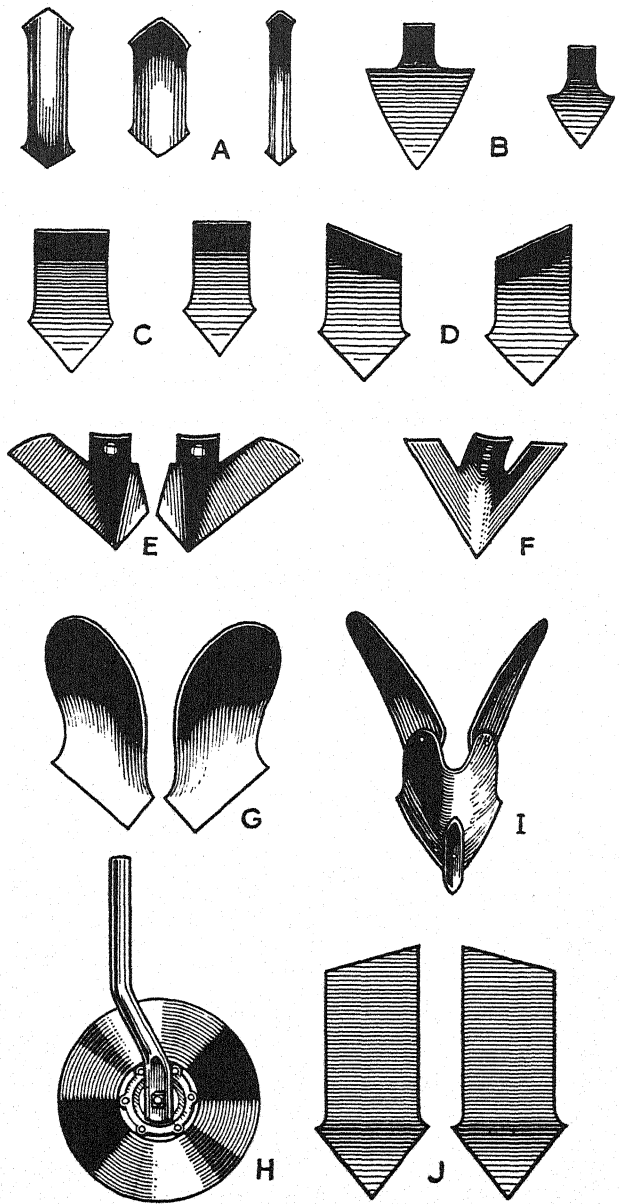


FIG. 127. Shovels and steels.

give the same result as the half sweep. The right and left moldboard hillers (*G*) are used for throwing the soil toward the row, which is called *hilling*. A disk-hilling attachment (*H*) is frequently used, particularly for hilling up potatoes. The disks replace the two shovels next to the row and can be set for hilling (inthrow) or for "barring off" (outthrow). The winged furrower (*I*) is supplied with a point to give good penetration. Special potato shovels (*J*) are also available.

Shovels are forged from soft-center steel or crucible steel.

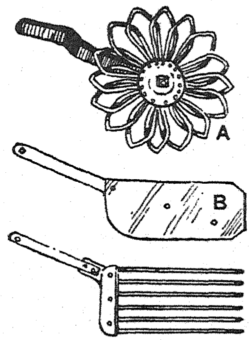


FIG. 128. Shields or fenders. *A*—Revolving. *B*—Open. *C*—Solid.

Shields or Fenders (Fig. 128). Three types of shields or fenders are used—the revolving, solid, and open types. These are attached to the cultivator gangs on the inside of the center shovels. They are used chiefly during early cultivations, to protect the young plants and to keep them from being covered by the soil. The open type and the revolving type have a desirable pulverizing effect on the soil.

Riding Cultivators

Riding cultivators are made in both single-row and double-row sizes. There are three principal types.

Shovel Cultivator (Fig. 129). This type is equipped with blades or shovels like those shown in Fig. 127. It is the most widely used of all three types and is a general-purpose implement. Because of the wide variety of shovels and attachments available and the wide range of adjustments possible, this cultivator can be used under many different conditions.

Disk Cultivator (Fig. 130). The disk cultivator is used to advantage on fields that have a large amount of grass or running vines growing between the rows. Fields that are infested

with quack grass, wild morning glory, etc., can be controlled with the disk cultivator. The revolving disks cut and turn up the roots so that they may be destroyed by exposure to the

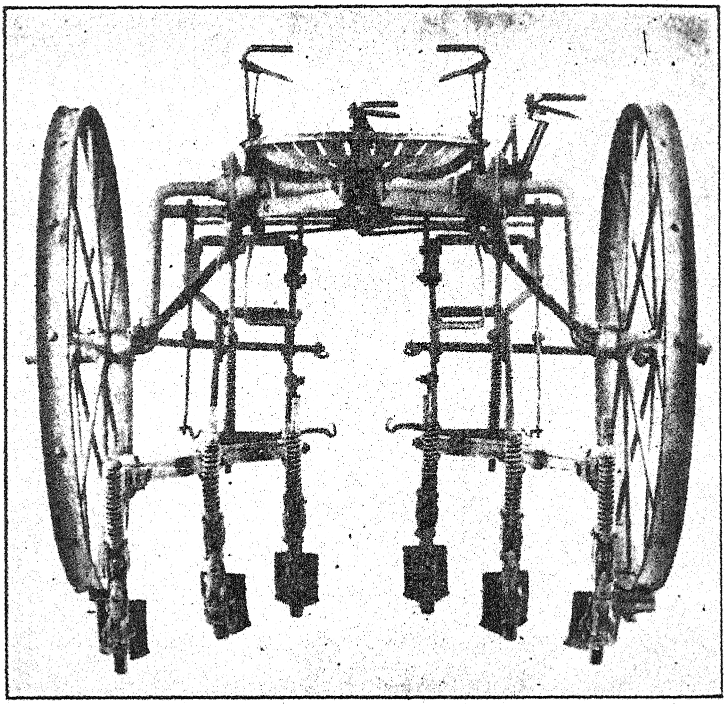


FIG. 129. Single-row **riding cultivator**, six-shovel type.

sunlight. Disk cultivators do excellent work in hilling up crops. The disk gangs have a wide range of adjustment. They may be set to throw the soil either toward or away from the plants.

Leveling bars are used behind the disks when it is desired to keep the soil level.

Surface Cultivators (Fig. 131). The surface cultivator is fitted with long, sharp blades. These do not penetrate deeply,

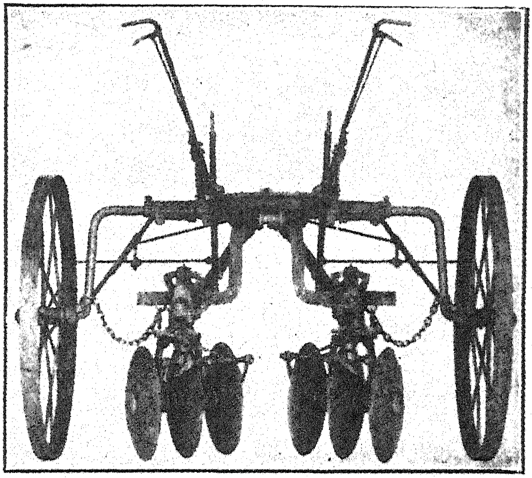


FIG. 130. Single-row disk cultivator.

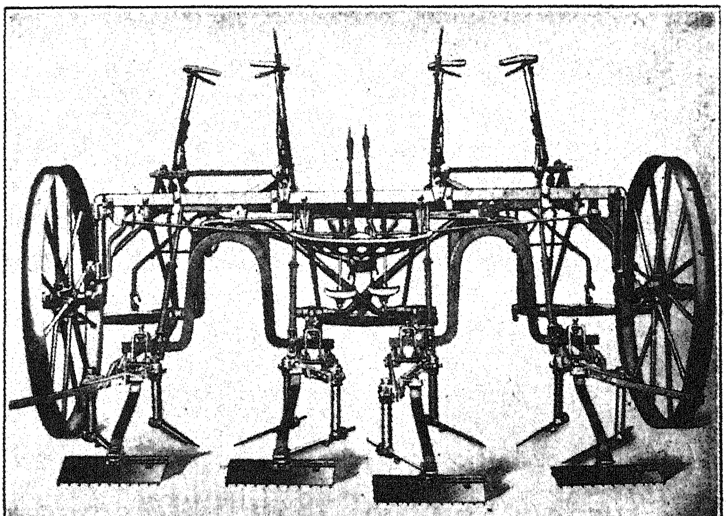


FIG. 131. Two-row surface cultivator.

but slice off weeds and work just below the surface of the soil. This type of shallow cultivation is very desirable at a late stage in the growth of the crop, when the root system of the plant is well developed.

Surface-cultivator attachments and disk attachments may be secured for shovel cultivators. The construction of the frame, wheels, lifting levers, etc., is very much the same for all three types. For this reason a detailed description of the construction of only one type of riding cultivator will be given here.

Construction and Principal Parts of Riding Cultivator (Shovel Type)

Wheels. Riding-cultivator wheels are higher than those used on the walking cultivator. The construction of the wheel hub and axle is illustrated in Fig. 132. At the inner end of the axle (a), the sand box or thrust bearing (b) is attached. This is built in halves (one half is removed in the illustration) and is clamped to the axle with bolts. The wheel box (c) is bolted to the hub of the wheel, as in plow wheels. The inner end of the wheel box ends in a collar which is retained in a recess of the thrust bearing. The opposite end of the wheel box is threaded to receive the hub-cap grease cup (d). This type of wheel cannot be adjusted in or out on the axle.

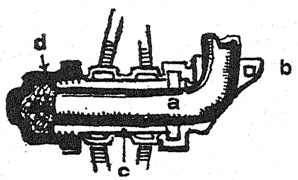


FIG. 132. Cultivator-wheel hub and axle.

Gangs. The construction of the gangs is similar to that of walking cultivators. Riding-cultivator gangs may be equipped with four, six, or eight shovels, the six-shovel equipment being the most common. Figure 133 shows the location of the shovels on the six-shovel cultivator.

Two principal methods of attaching the gangs are used in riding cultivators. One method, the same as that used for

walking cultivators, allows the gangs to pivot at the front end. The other method provides a rigid attachment between the front ends of the gangs and the bar, or arch, which shifts them.

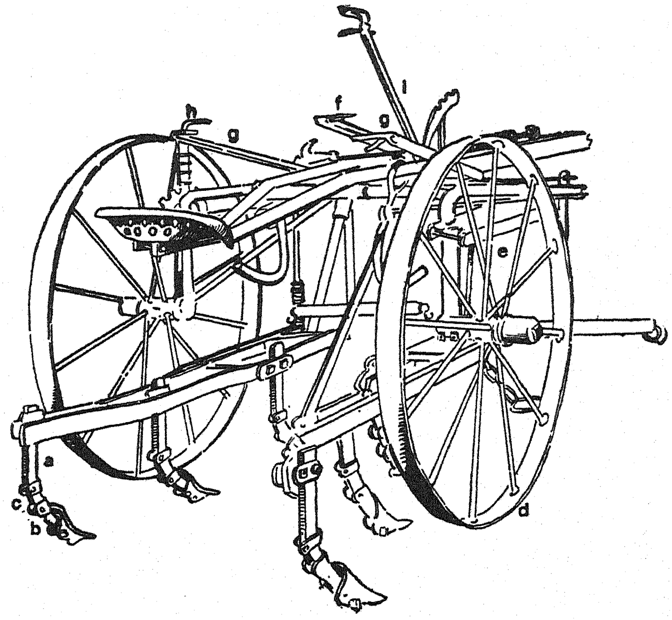


FIG. 133. Construction and principal parts of six-shovel riding cultivator.

Cultivator Control. There are several different methods of controlling or manipulating the gangs on riding cultivators. The most commonly used methods will be discussed here.

1. *Direct Foot Control.* In this type of cultivator, each gang is independent of the other. The gangs pivot at the front end, as in walking cultivators. The operator controls the gangs entirely by the action of his feet, for which stirrups are provided on the gangs.

This type of cultivator is favored by some farmers because very accurate and close work may be done with it. This

method of control is harder work for the operator, for he manipulates the gangs directly, without the aid of levers.

2. *Seat Shift or Pivot Frame.* In this construction the gangs are controlled by the swinging motion of the seat. The frame of the cultivator is attached to the rear end of the tongue, and the rear end of the tongue is supported by a large roller. The seat is connected by long steel bars to the front of the

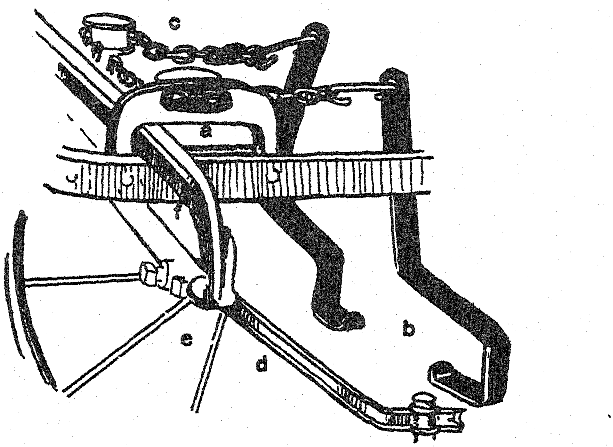


FIG. 134. Construction of parallel-gang, foot-shift control and combination control.

frame. These bars are pivoted under the axle, and the seat is thus made to act as a lever. A slight pressure by the operator in either direction on the seat causes the gangs to shift.

Footrests are provided on the gangs to make it easier to put pressure on the seat.

3. *Parallel Gangs: Foot Shift* (Fig. 134). In this type the gangs are rigidly connected at the front ends to the gang bar (*e*). A shifting bar (*f*) is bolted to the gang bar. The shifting bar is supported above the frame by rollers (*a*). The action of the foot levers (*b*) is transmitted by chains and pulleys (*c*). Both gangs are moved as a unit; they are rigid and always parallel.

4. *Pivot Axle.* The foot pedals are connected to the axles. A slight pressure on either foot lever shifts the axle and changes the direction of travel of both wheels, which, of course, control the gangs. The pivoting-wheel type is particularly useful for hillside work, and also very helpful in steering the cultivator. Where short turns at the ends of the rows are necessary, the pivoting wheels are very desirable.

5. *Combination Control.* A combination of Methods 3 and 4 is used quite widely. Pressure applied to the foot pedal not only pivots the axle but also moves the gangs sideways. The pivot-axle method alone is rather slow. With the combination control, when the operator presses on the pedal, not only does he change the direction of travel of the wheels but also, at the same instant, the gangs are moved sideways. This method is quick, and the problem of dodging the plants in crooked rows is made much easier.

The combination is made by connecting the arched bar (Fig. 134*f*) to the axle-crank arm (Fig. 134*e*). This method of control is used very largely on two-row cultivators.

Balance Frame. As the weight of all parts of the cultivator is supported by two wheels, it is necessary that this weight be evenly distributed. When the gangs are taken out of the ground, their weight, which was on the ground, is added back of the axle. This has a tendency to make the pole tip up.

Most cultivators are built to balance in either position. Two methods of balancing are used.

1. *Cranking Back the Axles As the Gangs Are Raised.* The device or lever used for lifting the gangs from the ground is connected to the axles. The axles crank backwards as the gangs are lifted, balancing the weight thus added.

2. *Shifting the Entire Cultivator Frame Forward As the Gangs Are Raised.* This is accomplished by suitable connections between the gang-lifting lever and the frame. When the gangs are raised, the whole frame, including the driver's seat, moves forward, thus balancing the machine.

Levers. Note that riding cultivators are usually equipped with several levers, although some leverless riding cultivators are made.

Master Lever (Fig. 133*f*). The master lever raises or lowers both gangs as a unit. It is often connected to the axles so that as the gangs are raised the axles are cranked backwards, in order to preserve the balance of the cultivator. In many cultivators this lever is attached in such a way that, as soon as the lever latch is released, the pull of the horses raises the gangs. This is called a *horse lift*. The master lever is used at the end of the rows for raising and lowering the gangs. It is sometimes called the *balancing lever.*

Gang Levers (Fig. 133*g*). A gang lever is provided for each gang. This lever is used to adjust the depth of the shovels. Either gang may be raised independently of the other. This is often necessary to clear the gang of trash or to pass over an obstruction.

Spacing Lever (Fig. 133*h*). A spacing lever is provided on some riding cultivators. It is used to space or change the distance between the gangs so that the cultivator may be quickly adjusted for any width of row.

Pole Lever (Fig. 133*i*). A pole lever is used on some riding cultivators. This lever makes it possible to keep the cultivator frame running level under all conditions. In cultivating uphill and downhill this adjustment is helpful in keeping the front and rear shovels penetrating to an equal depth. It is also a convenient means of leveling the frame when changing to horses of a different height.

Two-row Riding Cultivators

A two-row surface cultivator is shown in Fig. 131. The two-row shovel cultivator is similar in construction. It may be equipped with a forecarriage, which carries the weight of the front part of the machine.

Two-row cultivators are usually controlled and steered by the combination method described on p. 189. The action of the

foot pedals (Fig. 134*b*) causes the gangs to shift sideways and the wheels to pivot simultaneously.

A master lifting lever is usually provided so that all the gangs may be lifted at once. A spacing lever makes it possible to adjust the gangs to different widths between rows; this lever is used to adjust the spread of the gangs. By means of the spacing lever the shovels may be brought toward the plants or moved farther away from them. Each gang is also provided with a separate depth lever.

Two-row cultivators are equipped with three-horse or four-horse eveners. Special tractor hitches may also be secured. With them a two-row riding cultivator may be trailed behind a tractor.

Tractor Cultivators

Mounted or "integral" cultivators are the most popular. Levers and controls are conveniently placed so that all necessary field adjustments can be made from the seat of the tractor.

Some operators prefer to trail a cultivator behind the tractor, making cultivating a two-man operation. They claim greater accuracy in the field and find it more convenient to disconnect the cultivator so that the tractor can be quickly available for other jobs. Hitches are available, therefore, for trailing the cultivator.

Single-row, Center-mounted (Fig. 135). This design is mounted beneath the center of an automotive type of tractor. The two shovels next to the row are placed well forward, close to the front axle, and so respond quickly to the steering of the front wheels. One or more shovels are mounted in the rear to cultivate out the wheel tracks.

Two-row, Front-mounted (Fig. 136). Clear vision and quick dodging action are afforded by mounting two-row cultivators at the front of the tricycle type of general-purpose tractors. Both front and rear tool bars are controlled by one

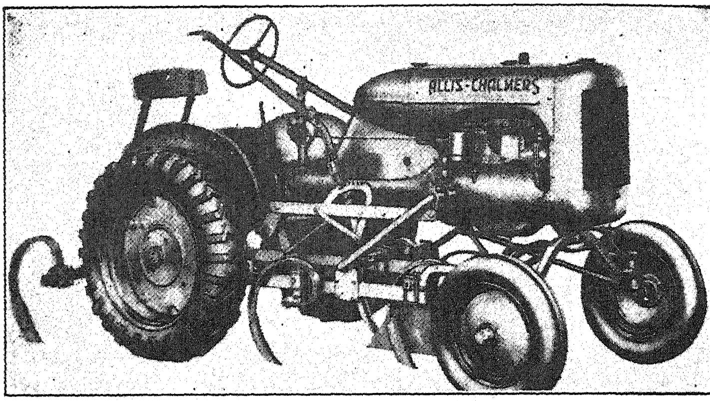


FIG. 135. Single-row, center-mounted tractor cultivator.

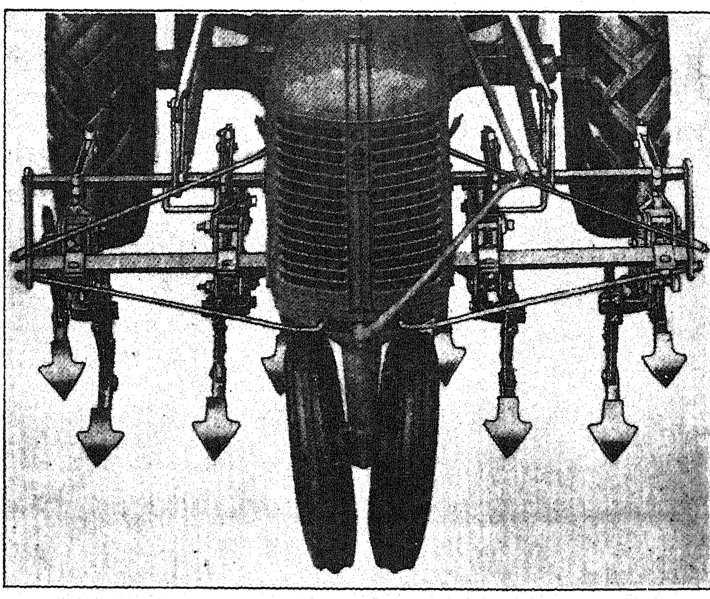


FIG. 136. Two-row, front-mounted tractor cultivator.

master lever. Designers strive to facilitate the work of mounting and dismounting the cultivator to make this task easy and quick. The sample illustrated is a "drive-in" type; the entire cultivating unit can be disconnected and dropped off as one piece.

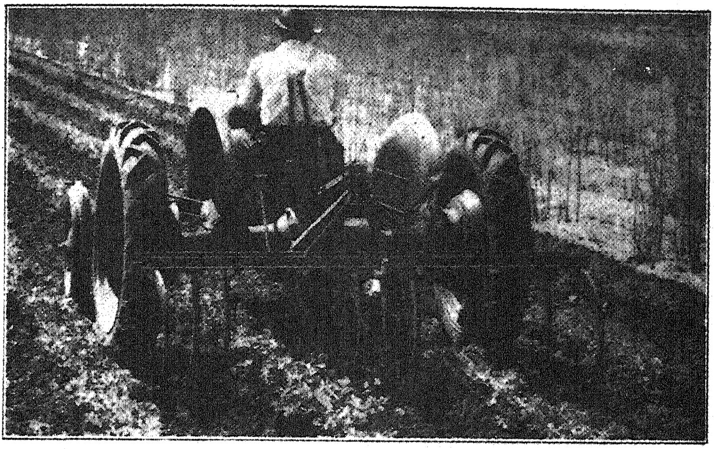


FIG. 137. Two-row, rear-mounted tractor cultivator.

Two-row, Rear-mounted (Fig. 137). This mounting is used on an automotive-type tractor, on which both front and rear wheels can be expanded to suit the row width.

The ball-and-socket-joint connection between the cultivator and tractor is flexible. A vertical fin or rudder extends downward into the soil at the center of the cultivator. As the front wheels are turned toward the left, the cultivator is also moved toward the left, thus permitting side movement or dodging.

Four-row, Front-mounted. Four-row cultivators are often used in the corn-growing regions, and to a lesser extent in regions where potato growing is a major enterprise. For the most satisfactory use, the crop should be planted with a four-row planter. Likewise for the best results with a two-row cultivator, the use of a two-row planter is desirable.

Because of the great width of four-row cultivators, special wheels are used to aid in supporting the weight. On such large units a hydraulic lift, operated by engine power, is commonly furnished.

Four-row Vegetable Cultivator. Multiple-row vegetable cultivators are center-mounted. Long, transverse tool bars beneath the center of the tractor provide for various settings and adjustments of the tools. Vegetable cultivators do not require much vertical clearance because the plants, in general, do not grow tall.

The entire front tool-bar assembly is controlled with one lever. The rear tool bar, carrying shovels to take out the wheel marks, is operated by the same master lever.

Lifting Methods. An easy and convenient means of lifting the shovels at the ends of the rows is essential. Three types of lifting mechanisms are used—manual, mechanical, and hydraulic.

Manual Lift (Figs. 135 and 136). One-row and two-row sizes may be satisfactorily lifted by a single hand lever, called a *master lever*, which raises all cultivator tools, both front and rear. A large spring is provided to assist in the lift operation, and it may be adjusted so that lifting is not arduous. When the shovels are lowered, the same lever acts as a pressure lever to insure good penetration. Though not as easy or convenient to operate as power-lift types, the manual lift is cheaper and lessens the original cost of the cultivator.

Mechanical Power Lift (Fig. 138). Engine power is applied through the power take-off shaft, a worm, and a worm gear to a lifting crank. When the operator steps on the trip button, the special power-lift clutch is engaged and the worm gear and crank revolve and lift both the front and rear cultivating rigs. After making half a revolution, the clutch is automatically disengaged and the rigs remain in the raised position. When the operator again steps on the trip button, the worm gear

and crank complete the revolution, and return the rigs to the working position.

Lifting springs are also used in the construction to lessen the load on the power lift. Some designs permit raising one side of a two-row cultivator independently of the other, if desired. Likewise the depth of cultivation may be regulated on either side by means of the power lift, and the rigs will be level in all working positions.

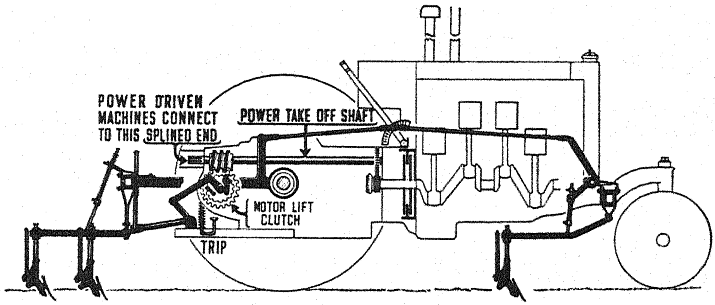


FIG. 138. Mechanical power lift.

Hydraulic Power Lift. As the number and variety of tractor-mounted implements increase, plows, seeders, planters, cultivators, listers, etc., an adequate power-lifting device becomes essential. Construction of this type is based on the well-known principle of Pascal's law of fluid pressure, "Pressure exerted by an external force on an enclosed liquid, is transmitted equally in all directions throughout the fluid, without loss."

The hydraulic unit is secured to the rear-axle housing of the tractor. The lowered position is illustrated in Fig. 139, and the lifting action in Fig. 140. In the lowered position, the piston is at the outer end of the cylinder and the lift (*D*) is horizontal. The gear pump (*E*) is driven by the power take-off shaft from the engine; oil from the reservoir enters the pump between the two gears and is carried between the teeth (which

act as small buckets) around the outside of the gear case, and is then forced upward as shown by the arrows.

The oil flows through the open by-pass valve (C), where it has free circulation back to the reservoir. The check valve (B) which controls the passage leading to the head of the

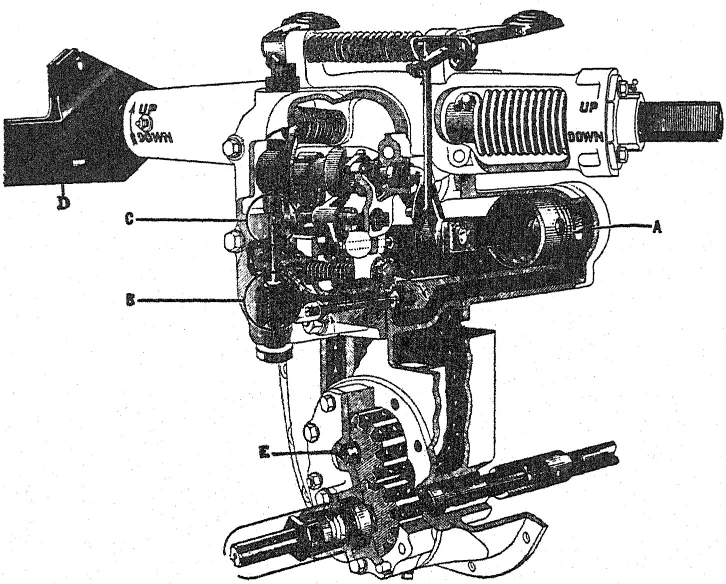


FIG. 139. Hydraulic lift, with implement in lowered position.

piston, is also open, but oil is not forced to the head of the piston as long as valve C permits free circulation.

When the foot pedal is depressed, valve C closes and valve B opens fully. Free circulation stops, and the oil is forced through valve B to the head of the piston. As the piston is forced backwards it causes crank F to move the lift arm (D) as indicated, thus raising the implements which are connected to the left arm. When the piston reaches the end of its stroke and the lift arm (D) is fully raised, valve C again opens, permitting free circulation, but valve B remains closed, trapping

the oil ahead of the piston and keeping the piston in the raised position.

When the pedal is again pressed down, both valves *B* and *C* will be open, permitting free circulation and also a return flow of oil from the head of the piston. This lowers the lift arm and implements.

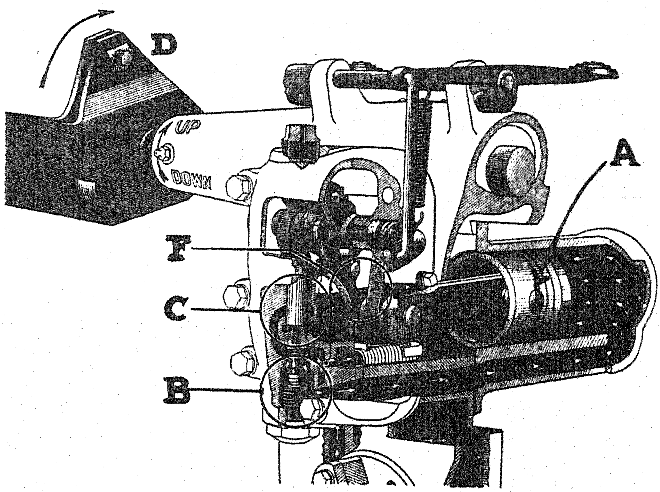


FIG. 140. Hydraulic lift, with implements raised.

In the construction shown in Fig. 141, the hydraulic pump is mounted over the power take-off shaft and is driven by it. A valve controls the flow of oil from the pump to the hydraulic cylinder. This valve is operated by the control lever near the seat. The tapered construction of the valve causes it to act as a throttling valve, regulating the rate of flow of oil to or from the hydraulic cylinder. Hence, the implement may be raised, or lowered gradually if desired, or stopped at any position during the lift. Thus the hydraulic mechanism serves both as a lifting device and a depth control.

Two links connect the tractor to the implement—the lower

links (right and left) draw the implement; the upper link resists the tendency of the implement to rise from the ground. The lower links are, therefore, under tension, and the upper link under compression. Should the load on the implement become too heavy, the upper link compresses the master control spring which, due to its connection with the hydraulic control valve, causes the implement to rise. In addition, a safety release valve is placed within the pump. It is normally held

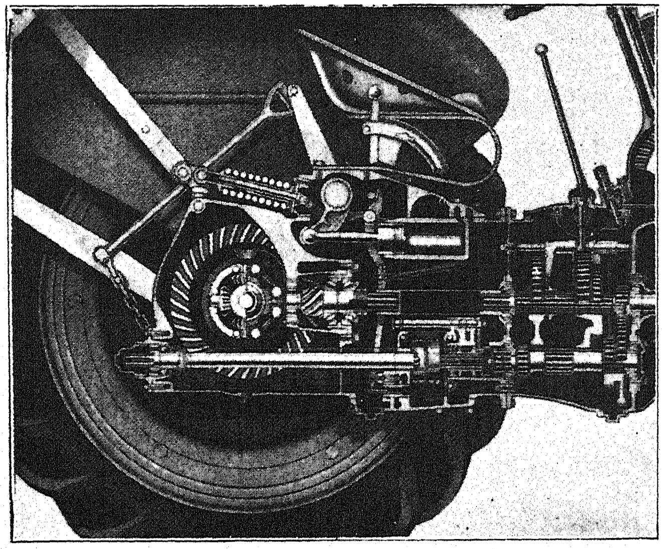


FIG. 141. Hydraulic lift.

closed, with a spring set at a definite, predetermined pressure. Should the pressure in the hydraulic cylinder become too great (in case the implement should become hooked beneath some immovable obstruction so that it could not be lifted) the safety release valve will open and prevent breakage of parts. When the control lever is pulled clear back, oil is then pumped to the hydraulic piston. The piston will be forced backwards until

the lift is completed, when a release valve is opened permitting free circulation of oil within the pump, but trapping the oil in the hydraulic cylinder so that the implements remain in the raised position.

Selective Hydraulic Lift (Fig. 142). This construction permits the operator (*a*) to lift the front section of an implement such as a cultivator before the rear section, (*b*) to lift either side independently of the other, (*c*) to lift and hold the implement to any desired intermediate working department, (*d*) to jack up the front or rear wheels of the tractor for changing tires or adjusting wheel-width treads.

The hydraulic pump (gear type) is driven from the front of the power take-off shaft and forces oil through the hoses to the three cylinders.

The rear cylinder is controlled by a special valve, so set that oil cannot enter this cylinder until the pistons in the front cylinders have reached the end of their stroke. This delayed action of the rear cylinder is advantageously applied to cultivators where the front section may be lifted at the ends of the row, but the lifting of the rear section is delayed until it, too, reaches the end of the row. In lowering the cultivator the action is the reverse; the front gangs are lowered before the rear.

To lift one side only, the operator may shut off the flow of oil to one cylinder, by a convenient lever, and permit the other to lift.

The hydraulic cylinders may be easily disconnected and fitted into the frame of a lifting jack. When used in connection with a suitable stand or with blocks, this provides a convenient method for jacking up the rear of the tractor for changing the width of tread or reversing wheels.

Action of Selective Hydraulic Lift

With the mechanism in neutral, the gear pump, driven from the power take-off shaft, forces oil from the reservoir

upward and out the by-pass valve, where it returns freely to the oil supply. When the operator pulls the control lever to position *B*, the by-pass valve is closed. Pressure builds up immediately and forces oil past the ball check valves, through the pipes and hose, to the various cylinders. Entrance of oil to the rear cylinder is delayed by a valve set to open at about

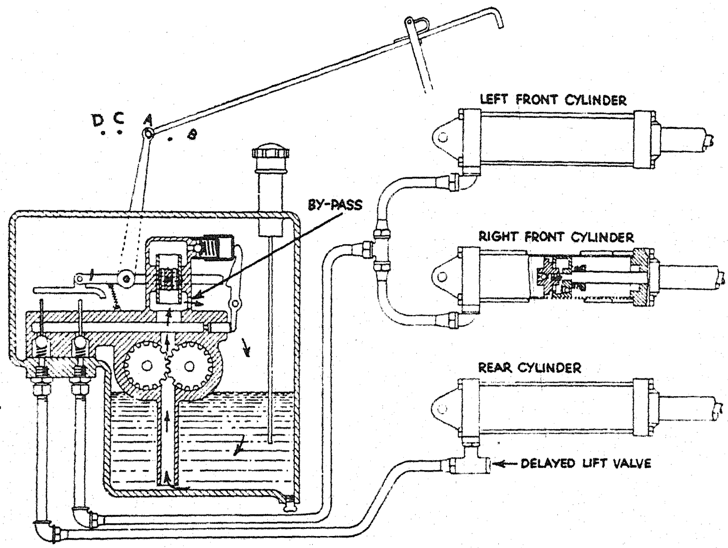


FIG. 142*A*. Selective hydraulic lift, neutral position.

300 pounds' pressure. Hence the oil enters the front cylinders, which complete their lift before the rear cylinder. The check valves trap the oil in the pipe, hose, and cylinders and hold the implements at any desired point in their lift.

When the cylinders have completed their lifting stroke, the oil reaches a pressure of about 500 pounds, passes through the holes (2) and forces open a relief valve (3). The oil then enters and presses the cap of the spring holder (4) against the rocking lever, causing the lever to disengage and permit all control parts to return to their neutral points (*A*).

To lower the front section only, the control lever is pushed

to position *C*, which opens the check valve communicating with the front cylinders and permits a return flow of oil from them.

To lower the rear section, the control lever is pushed to position *D*, which opens the check valve communicating with the rear cylinder and permits a return flow of oil from it. The delayed lift valve requires about 300 pounds' pressure for oil

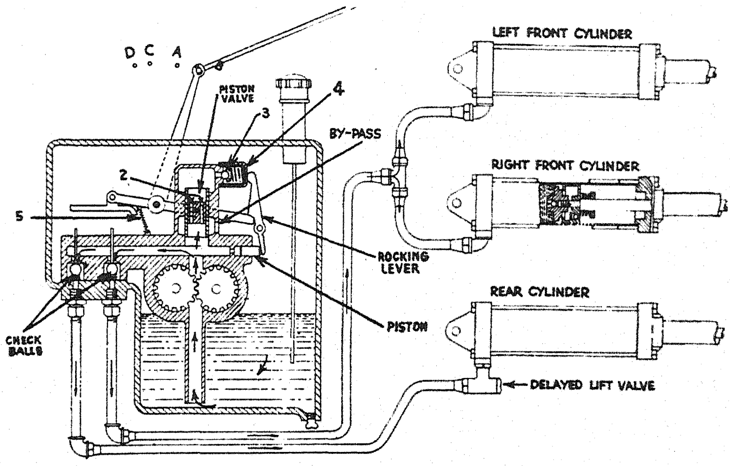


FIG. 142*B*. Selective hydraulic lift, with control lever in lifting position.

to flow through into the cylinder, but oil may flow freely through it in the opposite direction (when control is at *D*).

Pneumatic Power Lift. Exhaust gas is used for operating the power lift shown in Fig. 143. The manufacturer's literature (International Harvester Co.) describes its action as follows:

To Lift the Implement

The operator pulls the control handle (*A*) all the way out until the lug is caught by the hook. He thereby closes off the pressure valve (*B*) on the exhaust manifold so that the motor can pump exhaust gas into the lifting cylinder (*C*). The implement quickly rises.

For a short, part-way lift, the operator pulls the control handle out as above but holds it up so that the hook does not catch the

lug. When the implement reaches the desired height, he releases the control handle, which then returns to its neutral or holding position.

The Raised Position

As soon as the implement has reached its full height, the automatic release (*D*) "kicks off." The plunger causes the hook to let go the lug on the control rod, which then springs back to the neutral or hold position. The pressure valve (*B*) opens, allowing ex-

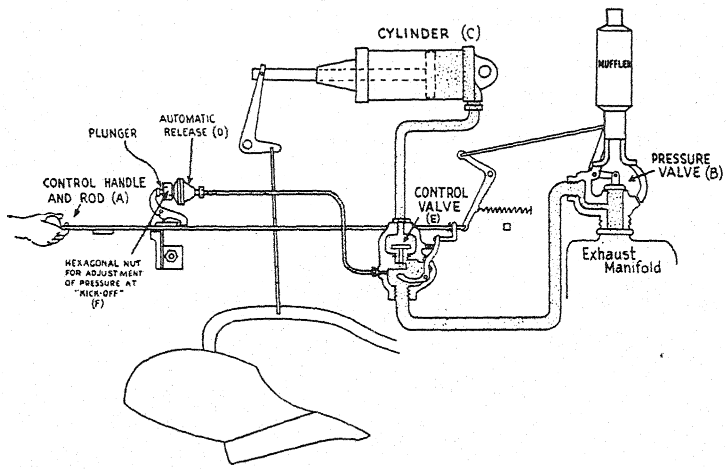


Fig. 143. Pneumatic power lift.

haust gas again to pass out into the muffler. The control valve (*E*) immediately seats itself, holding the pressure in the cylinder and keeping the implement in raised position.

To Drop the Implement

The operator lifts the control handle (*A*) and pushes it forward as far as it will go, thereby forcing the control valve (*E*) open. Exhaust gas escapes out the cylinder, past the control valve, through the open pressure valve, and out into the muffler. The weight of the implement causes the piston to return in the cylinder.

To let the implement down only a short distance, the operator pushes the control rod forward, as above. When the implement

has been lowered to the desired position, he pulls the handle back to the neutral or holding position.

SPECIAL CULTIVATORS

Field Cultivators. These are designed primarily for eradicating weeds on fallow ground. They cultivate all the ground in their swath. The working members are not spaced to straddle rows, although some types may be adapted for certain row crops. They are available in various widths in either horse- or

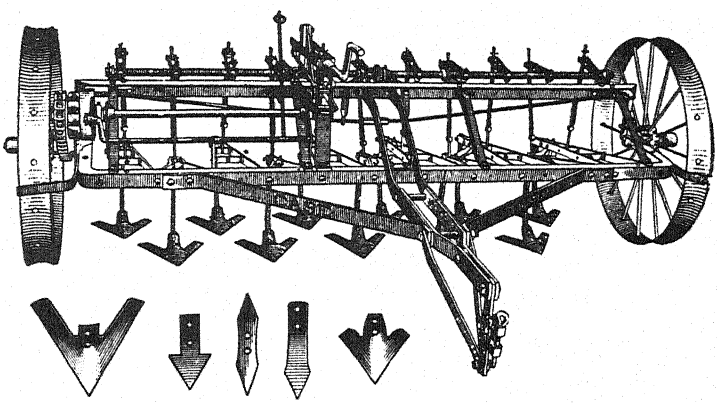


FIG. 144. Field cultivator and special shovels.

tractor-drawn models. The type illustrated in Fig. 144 with "duck-feet" sweeps (8 inches to 14 inches wide) may also be furnished with a chisel tooth, spear head or double point shovel. Spring teeth may be used instead of the stiff tooth.

Field cultivators are used for destroying noxious weeds and grasses, for cultivating summer fallow, alfalfa, and orchards. The ground surface is left rough and ridged, in good condition to retain moisture and lessen soil blowing. The heavier types may be used to deepen the seed bed and break up the formation of hardpan. They are well suited to orchard cultivation and may be adapted for subsoiling by using fewer and longer teeth.

Rotary Hoe. Operated directly over the rows of growing plants—or for "blind cultivating" before plants come up—this implement is quite effective in killing shallow-rooted weeds. It is fast and economical, and also breaks up surface crust without injuring the plants.

Two gangs of hoe wheels are used, with the hoes mounted free on the axle, 5½ inches apart. The hoes on the rear gang are spaced to work the ground left between hoes on the front gang.

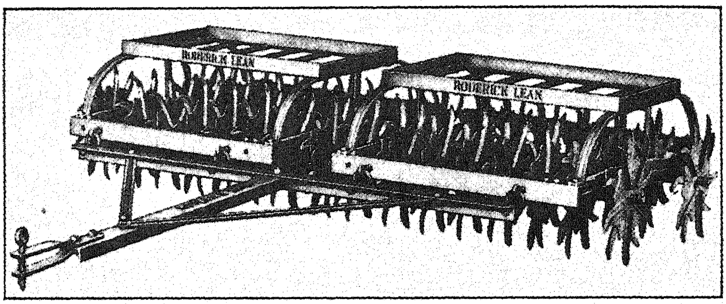


FIG. 145. Rotary hoe.

Weight boxes are provided in case added weight is needed for good penetration. The transport wheels act as depth gauges, but are usually clear of the ground when the hoe is working and the weight is carried on the teeth. Penetration of 1 to 3 inches and a speed of 3½ or more miles per hour are desirable for best results.

Rod Weeder. A long rod is forced from 1 inch to 5 inches below the surface of the ground and, supported by suitable bearings, it revolves while being drawn forward. The revolving rod (⅞ inches square or 1 inch round) destroys the weeds and is kept clean of roots by its own rotation. Power is applied to it with a chain drive from one rear wheel. The weeder rod rotates in the opposite direction from the rear wheel.

The widths vary from 9 feet to 36 feet, the 36-foot type being made in three sections.

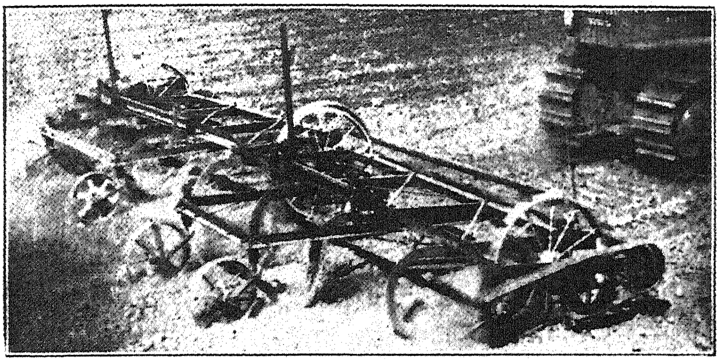


FIG. 146. Rod weeder.

Listed Crop Cultivators. The long runners of the sled type (Fig. 147) hold the machine in the furrow and guide it.

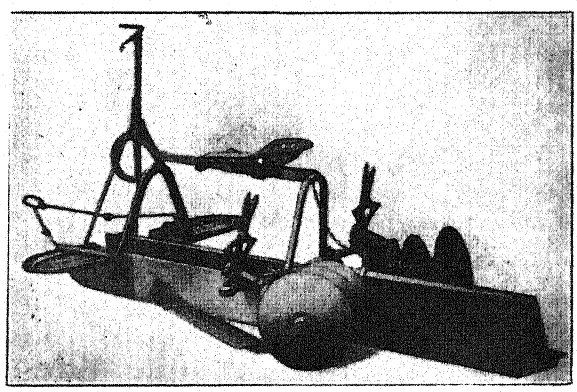


FIG. 147. Sled-type lister cultivator.

This shield prevents covering of the plants during the early cultivations. Side knives kill weeds and level down middles. The two-row, rear-mounted tractor type (Fig. 148) is held

in the furrow by a pair of furrow wheels placed ahead of the cultivating tools.

A combination of disks and shovels is used; the disks are usually set to throw away from the plants for the first cultivation; for the second, they are set for inthrow and the middles

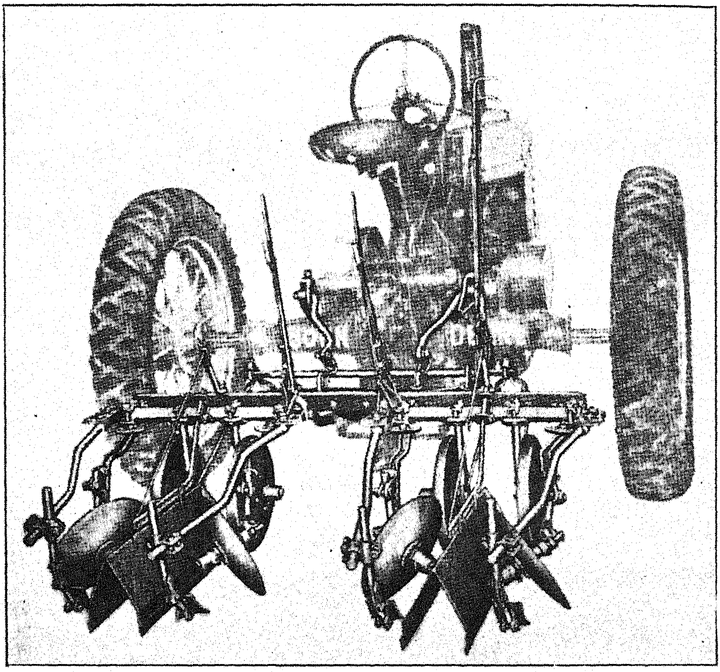


FIG. 148. Two-row, rear-mounted lister cultivator.

are leveled down with the rear shovels or knife attachment. Later cultivations usually require a standard cultivator.

Hooded shields are used to give full protection to the small plants and to prevent their being covered.

Weeders. During the early stages of plant growth, the weeder is quite efficient for killing weeds. It is light and requires little power to draw it. The one-horse size is 7½ feet wide, covering two rows of corn. It has three angle bars, each

containing thirty-nine light spring teeth. The teeth are closely spaced and all the ground is weeded carefully. A small farm tractor will easily operate a four-row weeder (15 feet or more in width).

Operating directly over the rows, the light, wirelike teeth flick out all the shallow-rooted weeds, without injuring the

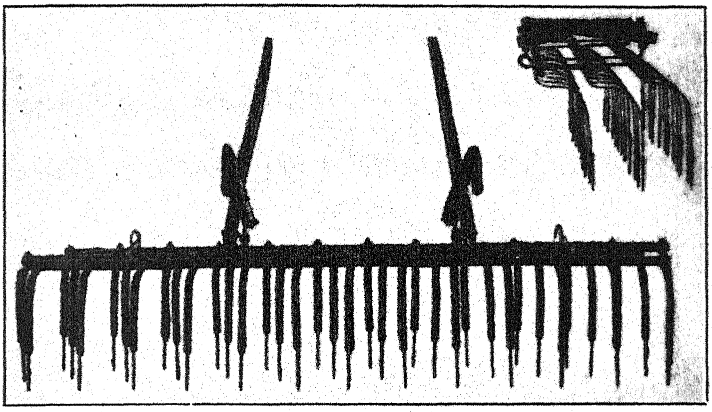


FIG. 149. One-horse weeder.

growing plants. Their use is economical because it eliminates the need for one or more later cultivations with a standard cultivator, which is slower and a more costly operation. Weeder attachments may be secured for straddle-row cultivators (Fig. 150).

OPERATING STRADDLE-ROW CULTIVATORS

As cultivating accomplishes a number of different purposes, many types of cultivators and various attachments and adjustments are necessary. A certain crop may be cultivated several times during the season. The conditions existing during early cultivations are quite different from those encountered later.

Early Cultivation. The shovels (or disks) may be set quite deep for early cultivation. The gangs may be set close together to cultivate the ground near the plants. Shields are

used in early cultivations to prevent small plants from being covered by the soil. Shovels should be set so that the soil is left level and kept from covering the young plants.

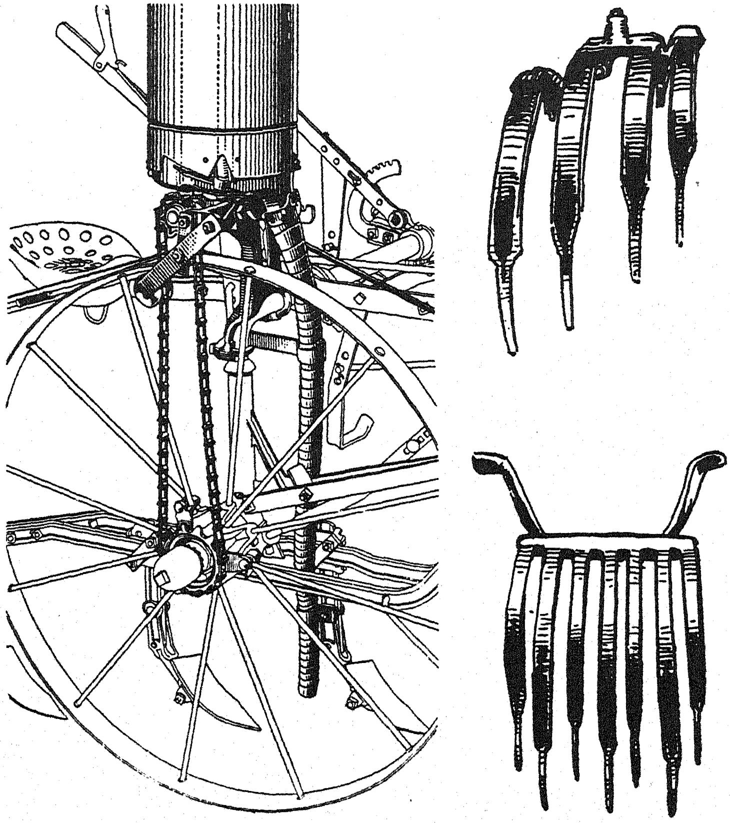


FIG. 150. Fertilizer attachment. Spring-tooth and weeder attachment.

Later Cultivation. As the root system of the plant develops, cultivation must be more shallow. Deep cultivation, when the plants are well grown, injures the roots and reduces the yield.

The gangs should be spaced farther apart than for early

cultivation. Half sweeps are often used in place of the two inside shovels (Fig. 127*E*) in order to prevent injury to the roots. The outside shovels may be turned slightly on the shanks to throw the soil in toward the row.

Surface cultivators or sweeps are often used for late cultivation. They work only the surface, slice off the weeds, and mulch the topsoil well.

Final Cultivation. The final tillage operation with many row crops is hilling. This consists in throwing the soil toward the row to form a ridge or hill.

Hilling may be accomplished efficiently with a disk cultivator or by using hilling shovels on a shovel cultivator. The

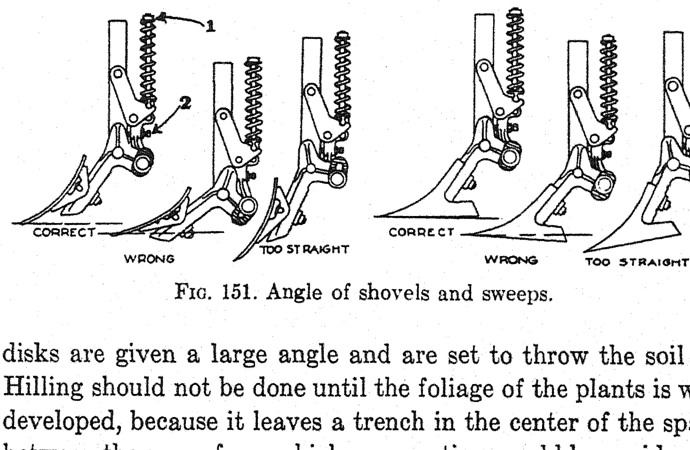


FIG. 151. Angle of shovels and sweeps.

disks are given a large angle and are set to throw the soil in. Hilling should not be done until the foliage of the plants is well developed, because it leaves a trench in the center of the space between the rows, from which evaporation would be rapid were there no shading by the plant foliage.

1. Choose suitable cultivating tools and adjust them correctly. The selection will depend upon the kind of work to be done, as explained on p. 181.

The first shovel, shown in Fig. 151, is set at the correct angle or pitch (135°), the second is too flat, and the third too steep. Poor penetration results from wrong pitch. The correct angle

for setting sweeps is also indicated. Set the shields as described on p. 183.

2. Lubricate all bearings, gang-shifting rollers, gang couplings, lever latches, spring trips, etc. Remove hub caps and fill them with grease.

3. Level the gangs. On horse-drawn cultivators the singletrees are adjustable vertically in the pendants. Hitching the

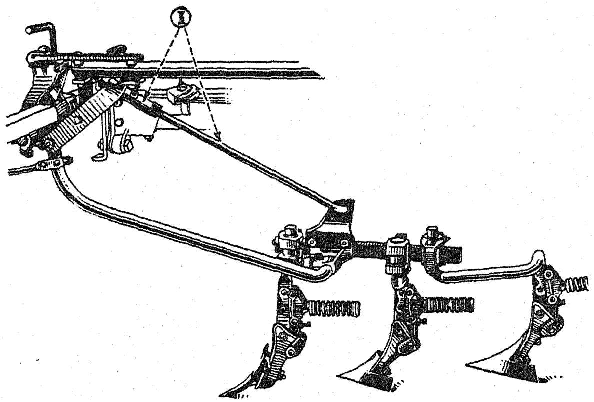


FIG. 152. Turnbuckle provided for leveling the gangs.

singletree high has a tendency to pull the front shovels more deeply into the ground and the rear shovels out of the ground. Hitching low has the opposite tendency. For average conditions the hitch should be adjusted so that the line of the traces, if extended, would pass through the pendant and strike the ground just at the rear of the front shovel.

The height of the pole must be adjusted so that the gangs are level, otherwise the shovels will not penetrate equally. If the pole tilts upward, the rear shovels will penetrate more deeply than the front ones; and the opposite will be true if the pole tilts downward. Some cultivators have a pole lever for this adjustment. Otherwise, such adjustment must be made by regulating the length of the straps attaching the neckyoke to the pole. The turnbuckle construction, shown in Fig. 152, is one

method of leveling tractor-cultivator gangs. Shortening the link with the turnbuckle will raise the rear of the gang.

4. Adjust and balance to suit the operator. The tension of the lifting springs should be adjusted so that lifting and lowering is made as easy as possible.

The balancing device (axle crank or frame shift) on horse-drawn cultivators should be adjusted to suit the weight of the driver. There should be no tendency of the pole to tip up when the gangs are raised. On some machines a lever is provided for balancing. In others, the seat may be moved to any position along the seat bars to suit the convenience of the operator and to balance the machine. On some cultivators foot pedals are provided with adjustable extensions for the comfort of the driver.

5. Adjust the tread. The distance between the wheels (called the *tread*) of a single-row cultivator should be the same as the distance between the rows, to allow each wheel to travel exactly in the center of the space between the rows. This adjustment is made by moving the axles in or out on the frame.

The tread of the tractor wheels must be adjustable for tractor-mounted cultivators. Several methods and combinations of methods are used to permit the necessary variation in tread. (See Fig. 153.)

(*a*) *Spacing Spools.* These may be placed between the wheel and hub.

(*b*) *Long, Rear Axles.* The wheels are moved in or out on the axle—usually a splined axle—and clamped at the desired position.

(*c*) *Concave Wheel.* The wheel center—a disk or spider—is "dished" or concave. Set with the concave side in, the tread is decreased. When the wheel is reversed—placed on the opposite side of the tractor—the tread is widened.

(*d*) *Reversible Rim.* This may be fastened to the inner or the outer side of the tractor wheel.

(*e*) *Reversible Lugs.* Reversible lugs hold the rim to

the wheel and may be bolted to the inner or outer side of the wheel.

The treads secured on a certain tractor, by combining methods *c*, *d*, and *e*, are illustrated in Fig. 153. When changing treads, the operator should always be sure that the pneumatic

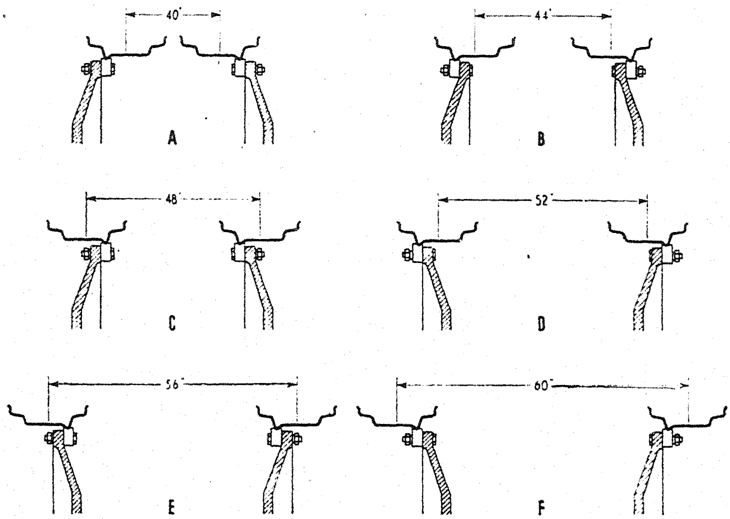


FIG. 153. Methods of varying the tread: concave wheel, reversible wheels, and reversible lugs.

tires are placed so that they will run with the tractor lugs pointing forward, as shown in Fig. 136.

6. Space the cultivating tools. The distance between the two shovels nearest the row may be adjusted by a spacing lever, or it may be necessary to shift the gangs where they are connected to the arch. The gangs should be set so that the cultivating tools will come as near to the row as desired, depending upon the type of cultivation needed.

The shovels on tractor cultivators may be adjusted horizontally where the rigs or beams are attached, or individual adjustment is made possible by a cross head.

7. Regulate the depth. Each side may be adjusted independently for depth with the gang lever. Individual pressure springs are provided on tractor cultivators. At the ends all gangs are raised with the master lever or automatic lifting device. Individual gang levers are convenient for ridding the shovels of trash. A lever stop or indicator is desirable in order that the depth may be the same each time.

8. Select a field plan. The following methods are used for single-row, horse-drawn cultivators:

Method 1. Raise the gangs at the end of the row. Turn around short, drop the gangs, and come back on the adjoining row. This method requires a very short turn at each end of the field.

Method 2. Some operators prefer not to make such short turns but to skip a row each time, at each end of the field. Thus they cultivate every alternate row as they progress across the field. Then they work back across the field in the opposite direction, cultivating the rows skipped in the first operation.

Method 3. Another common method is to skip one row each time the turn is made toward the uncultivated part of the field. The first row to be cultivated is row 1, which is at the very edge of the field. The return trip is made on row 4, the next trip across on row 2. The second return trip is on row 6. Then the rows are cultivated in the following order: 3, 8, 5, 10, 7, 12, etc.

If twelve rows are indicated on a sheet of paper and a line is drawn through them in the above order, this method will be clear. After the field is started, it consists simply in skipping one row each time on the uncultivated side of the field.

Method 4. For two-row tractor cultivator. The method shown in Fig. 154 is a practical way of cultivating with a tractor. Start on the left-hand side of the field with the tractor straddling the second pair of rows; turn to the

right at the end of the row and come back straddling the fourth pair of rows; then go over to the first pair. Now travel over to the sixth pair. Next straddle the third pair, then turn right and skip one pair of rows at the right of the sixth pair.

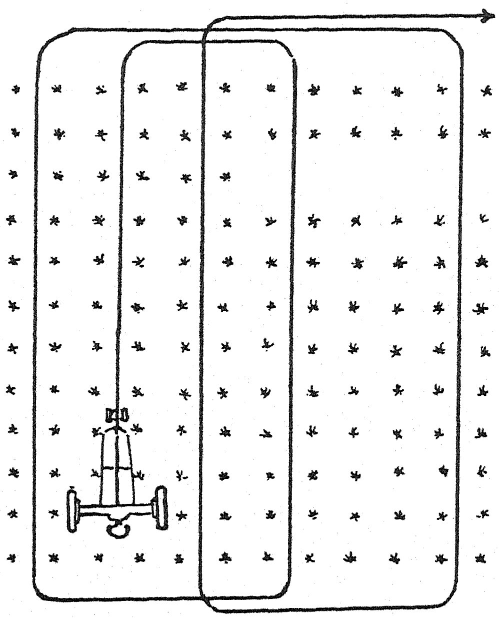


FIG. 154. Field plan for two-row tractor cultivator.

It will be observed in using this method that after getting properly started it is merely a matter of leaving two uncultivated rows each time when turning toward the uncultivated part of the field. The same method can be used by starting at the right side of the field.

It is always necessary to straddle a pair of rows, that is, two rows which were planted at the same time with the two-row planter. Using a two-row cultivator on a crop planted with a single-row planter is difficult and impractical.

JOB 12

TO REPAIR A STRADDLE-ROW CULTIVATOR

1. Get the owner's or operator's report on the condition of the cultivator, and other information as indicated in preceding repair jobs. Try to secure an instruction and repair catalog. The owner should have it on file.

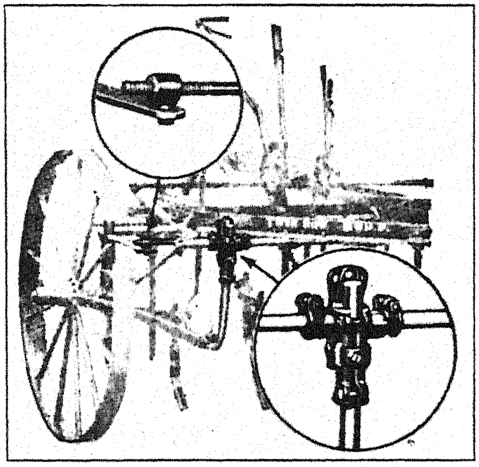


FIG. 155. Tie rod for aligning wheels.

2. Test and inspect all parts. If possible test the cultivator under working conditions. Try the cultivator control mechanism, levers, beams and their connecting bolts or rivets. Test wheel bearings and wheel alignment.

3. List the repair operations needed.

4. Order necessary repair parts.

5. Repair and align wheels. Test the wheel bearings by rocking the wheel on the axle to determine the amount of wear. Remove the wheels; clean and lubricate the axles thoroughly. Replace the sand bands, wheel boxes (Fig. 132*c*), and collars (Fig. 132*b*), if necessary. See that the wheels stand plumb and "toe in" slightly at the front. The tie rod connect-

ing the axles of the riding cultivator is usually adjustable by means of a threaded connection or similar device for aligning the wheels.

6. Tighten or replace worn bolts or rivets. Worn bolts or pins at any connection of the dodging mechanism cause hard steering and wheel wobble, resulting in inaccurate work. Wear at all points increases rapidly if worn bolts, rivets, and pins are allowed to remain in place. This applies especially to the frame, gangs, gang couplings, and lever ratchet.

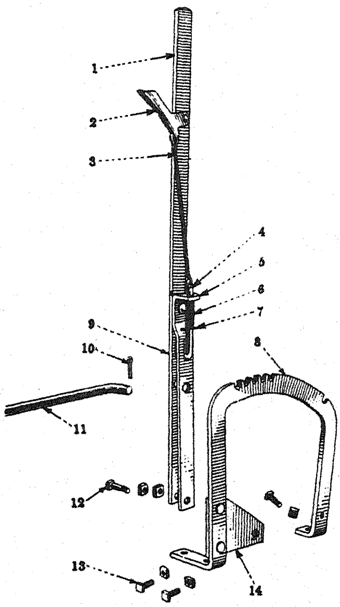


FIG. 156. Parts of a hand-operated lever. 1—Lever. 2—Latch. 3—Latch rod. 4—Spring bolt. 5—Guide. 6—Spring. 7—Cotter. 8—Quadrant. 9—Lever spring box. 10—Cotter. 11—Lifting link. 12, 13—Bolts. 14—Support plate.

7. Repair and adjust all levers. Test each lever and determine whether the lever detent enters the notches of the lever quadrant properly. Detent springs may become rusted or stuck. Tighten or replace the bolts or rivets in lever quadrants as required. (See Fig. 156.)

Adjust levers and lifting rods so that all gangs may be lifted and lowered evenly with the master lever, or automatic lifting device. On most tractor cultivators both the front and rear sections should lift simultaneously and, when lowered, all the shovels of all sections should touch the floor at the same time. Lift rods should be adjusted to permit the tool-holding beams to run level and the shovel shanks (standards) to be vertical.

8. Adjust lifting springs and lift rods. These springs are designed to aid in lifting the tool gangs, particularly when the

manual lift is used. Increasing their tension makes lifting easier, but too great tension makes it difficult to lower the gangs. A proper balance between the two extremes is required.

By lowering the lift collar one can hasten the time of lifting the individual gang. Raising the lift collar toward the upper end of the lift rod will delay the time of lift. All gangs should lift simultaneously, unless a delayed-lift mechanism is used, such as described on p. 200.

9. Adjust pressure springs. Pressure is increased by loosening the setscrew and changing the collar to a higher position. The pressure on all gangs should be set about equal, although the exact pressure requirement can best be determined in the field.

10. Repair the cultivating tools. Remove the shovels. Sharpen them on the grindstone by grinding on the reverse side of the shovel. Try to maintain the original shape or bevel. Remove any rust spots with emery paper. Replace the shovels on their shanks and adjust the pitch of each. See that bolts do not project above the surface of the shovel.

Make a supply of wood break pins if they are needed.

Sharpen disks and overhaul disk bearings (on disk cultivator) in the same manner as described for disk harrows.

Remove and sharpen surface blades (Fig. 131) on the grindstone, grinding them on the underside. Try to maintain the original shape.

11. Repair the spring trip. Disassemble all parts of the spring trip and clean it thoroughly. Remove all rust and lubricate the parts. Reassemble and, with light spring tension, test the action of the spring trip. Then readjust the spring tension and the angle of the connecting links, with the setscrew provided. (See Fig. 126.)

12. Prepare the cultivator for storage. Coat the shovels, disks, or blades with oil or grease to prevent rust. Paint all other parts of the cultivator.

CHAPTER VI

MOWERS

The chief use of the mower is to cut grass for hay, but it also is often used for cutting other crops. It is an excellent example of the labor-saving value of farm implements in contrast to the hand method of mowing which was extremely slow and laborious. The operator of a modern 5-foot cut mower, drawn by a team of horses, will cut up to 10 acres per day. A tractor mower with a 7-foot cutter bar will cut up to 25 acres per day.

The mower is designed to meet many different conditions. It must cut fine or coarse grass cleanly whether the stand is thick or thin. It requires adjustments and controls necessary to cut close to the ground and yet avoid hitting projecting stones, stumps, or other obstacles. The cut grass should be left in a neatly piled row, or swath, so that it can be easily handled in the later haying operations.

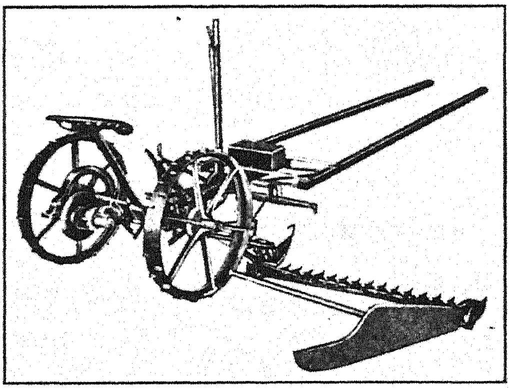
Types and Sizes

The size of the mower is expressed by the width of cut, which is determined by the length of the cutter bar.

Horse-drawn Mowers. The one-horse mower with a 3½-foot cutter bar, shown in Fig. 157, is used on small farms, lawns, parks, etc. For general farm work, 5- and 6-foot mowers are commonly used and are drawn by two horses. Seven-foot mowers may also be obtained. These are drawn by two horses or by a tractor.

Figure 158 shows a special hitch used to adapt a horse-drawn mower for tractor operation. With this hitch, the cutter bar may be raised and lowered from the seat of the tractor

by means of a rope. The hitch is offset to prevent the tractor from traveling over the standing grass.



Massey-Harris Harvester Co.

Fig. 157. One-horse mower.

Tractor Mowers. The tractor mower shown in Fig. 159 is designated as "semimounted." It may be attached to any make of tractor having the standard location of the power-

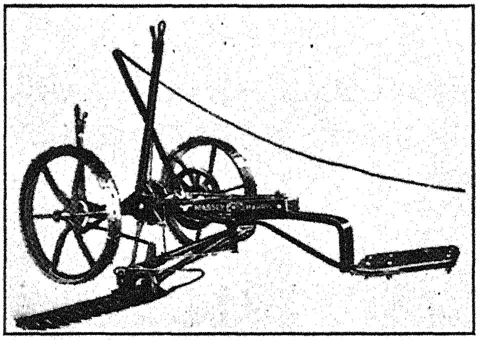


Fig. 158. Tractor mower.

take-off shaft. The weight of the mower (approximately 600 pounds for a 7-foot cut) is carried on three points—two caster wheels and the rear of the tractor.

A typical method of transmitting power from the tractor to the crank wheel of this type is illustrated in Fig. 160. The upper shaft is, in effect, an extension of the tractor power take-off. The two are connected through a universal joint.

An adjustable slip clutch (see Fig. 160) prevents damage should the sickle become wedged with small stones, pieces of wood, wire, or other small obstructions.

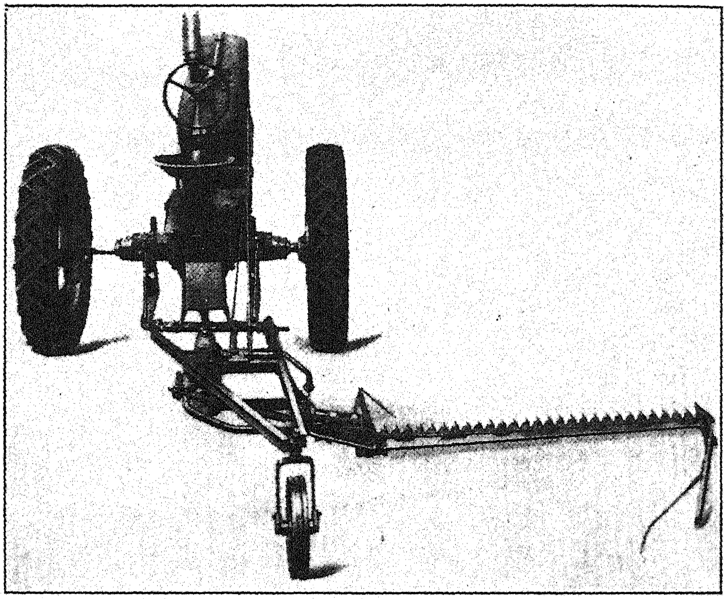


FIG. 159. "Semimounted" or trailed tractor mower.

If a large obstruction such as a rock or stump is encountered, the break-away mechanism is released and the entire mower unit is forced backwards. Backing the tractor recouples the release mechanism. When the mower unit moves far back, the drive shaft assumes such an acute angle at the universal joint that the shaft cannot function. In this event, an automatic safety catch, on the universal joint, disconnects the driven

half of the universal joint and no power is transmitted to the mower mechanism.

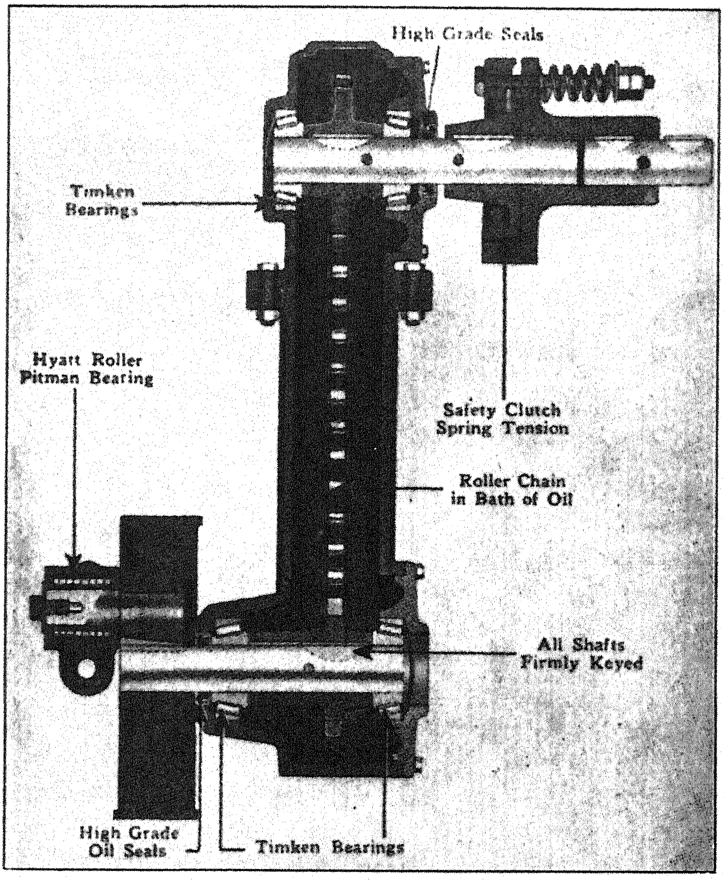


FIG. 160. Chain-drive power transmission for tractor mower.

The rear-mounting mechanism shown in Fig. 161 employs a belt drive, which carries power from the power take-off directly to the mower crank shaft. No gears or universal joints are used.

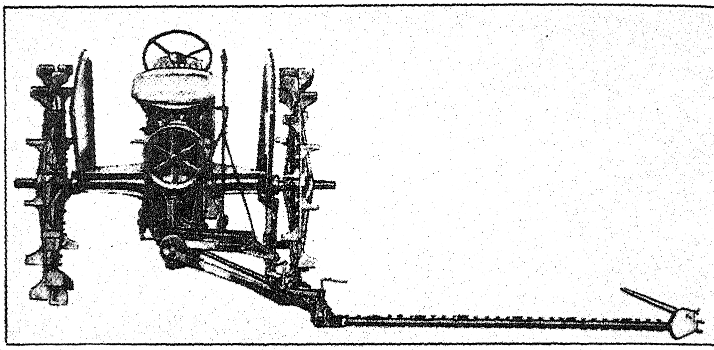


FIG. 161. Rear-mounted tractor mower with belt drive.

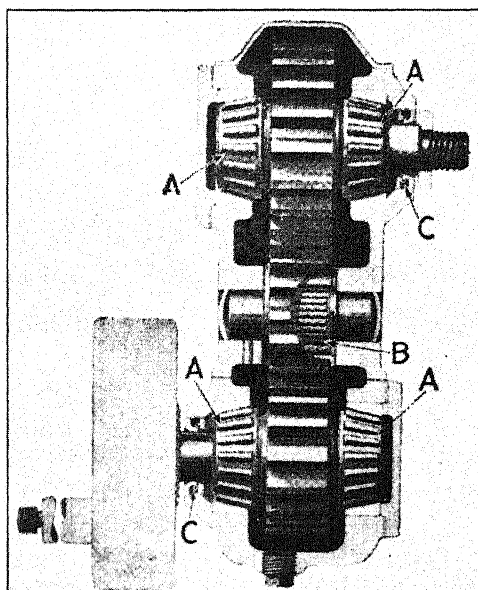


FIG. 162. Gear-drive power transmission for tractor mower. *A*—Tapered roller bearings. *B*—Straight roller bearings. *C*—Thrust bearings.

The break-away safety release is used, but is linked to the tractor clutch pedal. As the cutter bar moves back, it depresses the clutch pedal, stopping the forward motion of the tractor as well as the movement of the mower knife.

Lifting levers and a leveling lever extending forward from the mower are accessible from the tractor seat.

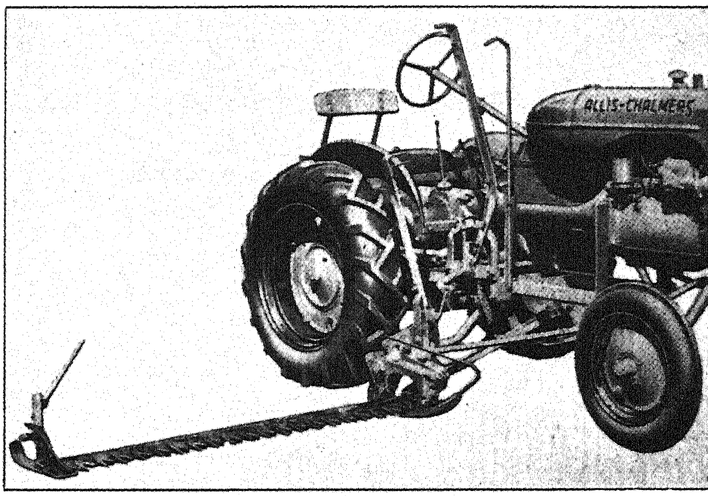


FIG. 163. Center-mounted tractor mower.

Rear-mounted mowers or semimounted, trailed mowers are easily attached and detached. Their position does not afford the operator as good vision of the work as does the center-mounting mechanism (Fig. 163). The control levers, too, are more conveniently reached on center-mounted mowers.

The power-transmitting parts for a gear-driven, rear-mounted mower are shown in Fig. 162. Tapered roller bearings with spring-loaded oil seals, to prevent oil leakage, are used on the drive shaft and on the crank shaft. A straight roller bearing is used on the idler shaft (*B*).

The center-mounted mower (Fig. 163) is belt driven from the power take-off shaft. The mower crank shaft extends for-

ward from the rear of the tractor, carrying the power to the mower crank wheel which is situated beneath the approximate center of the tractor. No gears are used between the power take-off and crank wheel. In the particular mower illustrated, the drive is by the V belt, the tension of which can be adjusted to permit slippage if the sickle becomes wedged. By removing shims from the top sheave and by adding shims to the lower sheave the speed of the sickle may be increased.

Transmission of Power in Ground-driven Mowers

Wheels. Both main wheels are drive wheels. They are made of cast iron. Lugs, cast as an integral part of the rim of the wheel, give traction and lessen slippage, which would cause the working parts of the mower to stop, and grass to be left uncut.

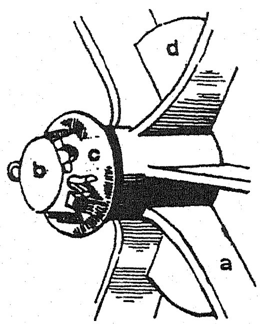


Fig. 164. Main wheel and axle.

The wheels are retained on the main axle with a take-up washer and cotter pin (Fig. 164*b* and *c*).

The motion of the drive wheel is transmitted to the main axle by means of ratchets and pawls. The construction is the same as that used in drills. (See Chapter III, p. 118.) The ratchets form a part of the inside of the wheel hubs (*d*). A pawl holder with pawls and springs is pinned securely near at the ends of the main axle.

The pawls should be assembled so that forward motion of the wheels will drive the axle. Reversing the drive wheel should allow the pawls to slip over the ratchet; the axle will not move, and a clicking noise will be heard when the wheels are turned backwards. Pawls for the left side may be different from those for the right, and it is possible to assemble them incorrectly.

Main Axle. The main axle is a straight steel shaft, its size and thickness depending upon the size of the mower. The

axle of the 5-foot mower is about $4\frac{1}{2}$ feet long. Roller bearings are used at each end of the main axle, as indicated in Fig. 165.

Frame. The main frame is made of one piece of cast iron. In the construction shown, it forms a housing for the axle, gears, countershaft, and crank shaft, and permits all these parts to run in a bath of oil. Oil seals are provided toward the outer ends of the axle and at the front end of the crank shaft, to prevent the leaking of oil from the reservoir.

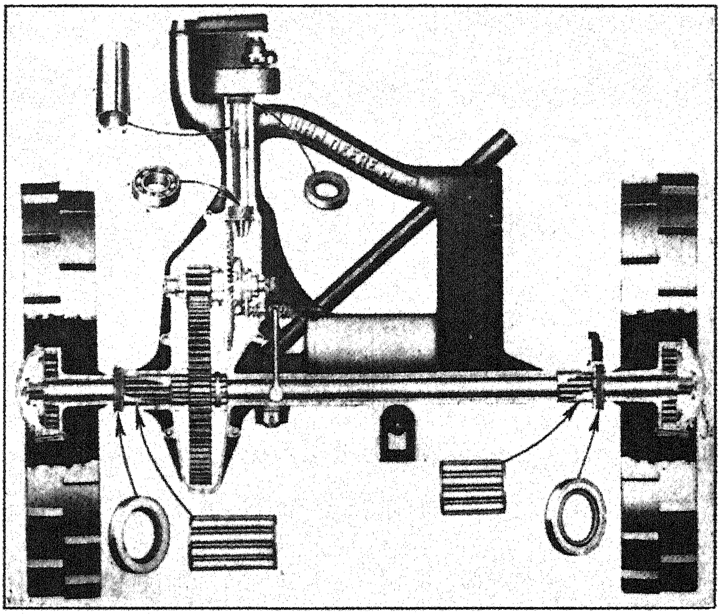


Fig. 165. Transmission of power in ground-driven mower.

Countershaft, Gears, and Clutch. The power from the drive wheels is transmitted by the pawls through the main axle to the main spur gear (Fig. 165). This meshes with a small spur pinion which is on the end of the short countershaft. Whenever the mower is drawn forward, the countershaft revolves.

The clutch (Fig. 166) is keyed to the countershaft and always revolves with it. It may be moved along the shaft by means of the clutch-shifting fork which is operated by a small foot lever. When the clutch is moved to the left it engages

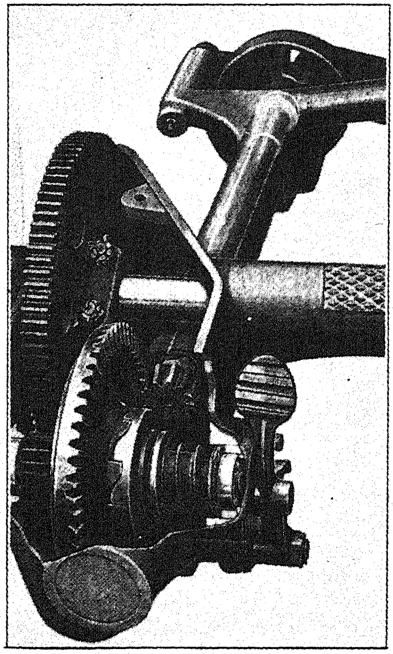


FIG. 166. Spur gears, bevel gears, clutch, and countershaft.

with the large bevel gear. This connects the bevel gear to the driving power of the main wheels. The bevel gear turns only when the clutch is engaged.

A small bevel pinion is keyed to the end of the long crank shaft. This meshes with the bevel gear and is driven by it. An adjustment is provided in most mowers for taking up the wear between the bevel gear and the bevel pinion.

Crank Shaft and Crank Wheel (Fig. 165). The crank shaft, although at a right angle to the countershaft, is driven

by it. This is made possible by means of the bevel gear and pinion (Fig. 166). The bevel pinion is screwed onto the upper end of the crank shaft, and the crank wheel is keyed to the lower end. One bearing is provided at each end of the crank shaft. These bearings are lined with cylindrical bushings, or anti-friction bearings.

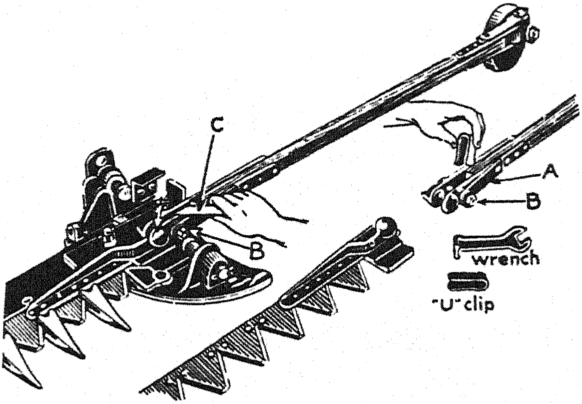


FIG. 167. Connection of pitman to the sickle. *A*—Latch for pitman bolt. *B*—Pitman bolt and nut. *C*—Wrench for attaching pitman.

The cast-iron crank wheel is keyed or screwed to the front end of the crank shaft. A wrist pin is driven through the crank wheel and riveted in place at the position shown. (Fig. 168.) The outer end of the wrist pin is threaded for the wrist-pin nut.

Pitman (Fig. 167). The pitman connects the crank wheel to the cutting knife, or sickle. It is usually made of wood, although steel pitmans are also used.

The connection of the pitman to the crank is made by a renewable box (Fig. 168*A*). This is known as the pitman box and is lined with bronze or babbitt where it fits over the wrist pin. Some mowers are furnished with a ball or roller bearing, or with a "needle" bearing such as shown in Fig. 333. This bearing is subjected to severe strain, and will heat up quickly

if not well supplied with the proper quality of lubricant. A lubrication fitting is supplied for this purpose.

The pitman box is attached to the wood pitman with metal straps and a bolt. The cone-shaped ends of the straps fit into a tapered hole in the pitman box, making a swivel connection which greatly lessens the strain and makes the box practically self-aligning.

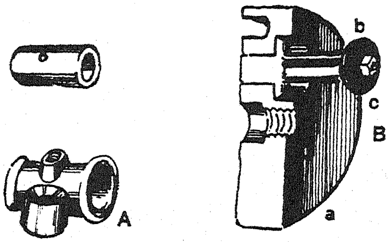


FIG. 168. Crank-shaft bushing, pitman box (*A*); cross section of crank wheel and wrist pin.

Metal straps (Fig. 167) are also used to connect the lower end of the pitman to the sickle. The ends of these straps have sockets which are sprung over the ball on the end of the sickle (*C*). Then the connection is tightened with the pitman bolt. A latch (*A*) is provided to keep the nut tight.

The pitman changes the revolving motion of the crank wheel into a reciprocating motion, which transmits to the sickle.

Cutting Mechanism

The various parts of the cutting mechanism are essentially the same in tractor mowers and ground-driven mowers. The actual cutting is accomplished by two parts:

(*a*) the moving sickle sections; (Fig. 169*a*).
(*b*) the stationary guard plate (shown in solid black at *b*).

These two parts make a shearing contact. There are many sections in the sickle and many guard plates, but each set acts in the same manner.

Both sides of each sickle section and both sides of each guard plate act as shears. On the outward stroke of the sickle, one side of the section cuts; on the return stroke, the opposite side cuts.

The sickle of a standard 5-foot mower has twenty sections and twenty guard plates. This means that there are forty sets

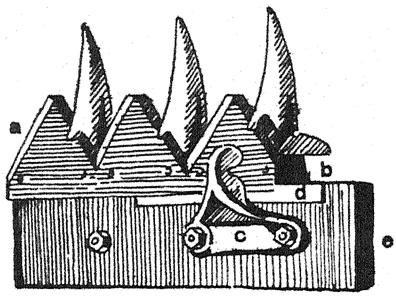


FIG. 169. Detail of cutting mechanism.

of shearing or cutting contacts. To keep all of these cutting properly, certain other parts are necessary.

The sickle clips (Fig. 169*c*) press down on the sections so that they make a close contact with the guard plate (*b*), which is the underside of the shear. The necessity for this may be easily illustrated with a pair of shears that have loose blades.

The wearing plates (*d*) provide a runner or support for the underside of the sickle. When badly worn, they allow the sickle to become loose and flop up and down. When this occurs the section and guard plate do not meet properly and the grass is torn loose instead of being cut.

The guards (*f*) carry the guard plates (*b*). One guard is provided for each section. The function of the guards is to direct the grass toward the cutting sections in such a manner that it

may be cut to the best advantage. The long fingers of the guards support the grass while it is being cut, pick up tangled grass, and prevent the sections from striking obstruction in the field.

The relative positions of the parts of the cutting mechanism are shown in Fig. 170. The edges of the guard plates (also called ledger plates) are roughened or serrated. These serrations support and hold the grass while it is being cut and prevent the shearing action of the sickle from pushing the grass away uncut.

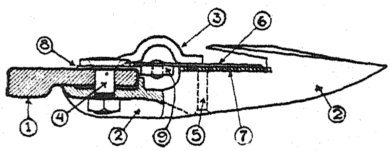


Fig. 170. Cross section through cutting mechanism. 1—Cutter bar. 2—Guard. 3—Knife clip. 4—Bolt. 5—Rivet. 6—Knife. 7—Guard plate. 8—Wearing plate.

The knife clip (3) should press the knife sections snugly down against the guard plates. Otherwise, grass will be wedged between the two and poor cutting will result. Knife clips may be bent down with a hammer.

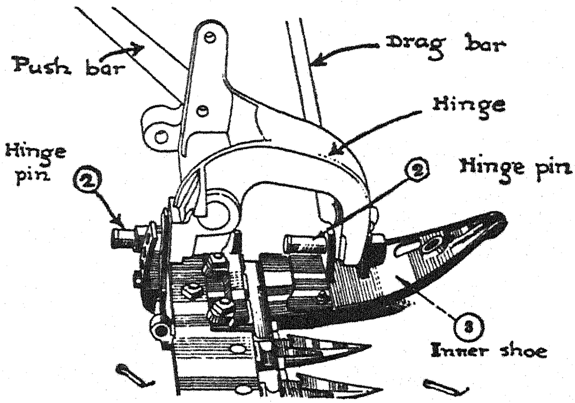
The heavy cutter bar (1) has all the guards bolted to it, and also the wearing plates on which the knife is supported. The cutter bar tapers slightly toward its outer end, but is strongly made to maintain accurate alignment of the many parts of the cutting mechanism.

The large inner shoe (Fig. 171) supports the inner end of the cutter bar. It acts as a runner for the cutter bar when the mower is in operation and is provided with a sole which is easily replaced when worn. The sole may be adjusted by means of a bolt at the rear of the shoe.

The smaller outer shoe supports the outer end of the cutter bar. This also has an adjustable sole. The pointed front of the

outer shoe acts as a divider, and separates the standing grass from that which is to be cut, leaving a clear, distinct line of uncut grass.

The grass board is bolted to the outer shoe. It is usually set to follow the contour of the ground and throw the grass over



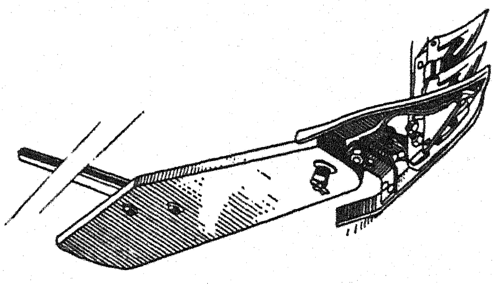


FIG. 171. *Upper*—Inner shoe and hinge. *Lower*—Outer shoe, with grass board and grass stick.

toward the center of the cutter bar. This is to provide a clear space in which the horses or tractor may travel when cutting the next swath. It also makes raking up the hay much easier.

The grass stick is bolted to the inside of the grass board. It assists the grass board in laying the cut grass in a well-piled row or swath. It is adjustable for high or low grass.

Levers and Controls

Ground-driven mowers are provided with three levers.

The large hand lever (Fig. 172) is called the lifting lever.

Regular-lift mowers have the hand-lift lever designed to raise the cutter bar a maximum height of about 13 inches at the inner shoe and 44 inches at the outer shoe. The knife will continue to operate in this lifted position.

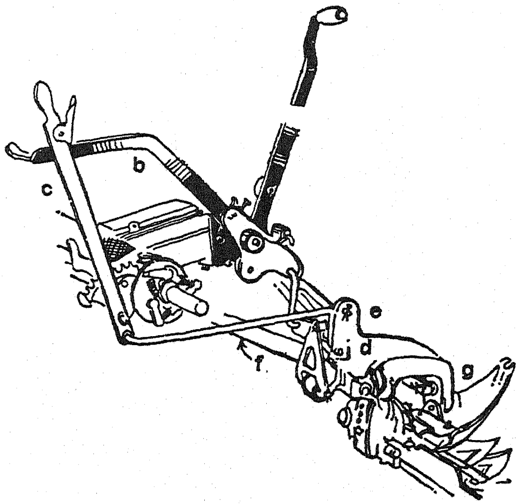


Fig. 172. Levers used on a standard type of mower.

To place the cutter bar in a vertical position, on regular lift mowers, the operator must leave the seat and complete the lift manually. Attachments can be secured for changing regular lift mowers to vertical lift.

Vertical-lift mowers are so designated because the hand lift lever is designed to raise the cutter bar completely to a vertical position. As the bar approaches its vertical position, the clutch is automatically disengaged and the cutting mechanism stops; when the bar is lowered again the clutch is reengaged.

Vertical-lift mowers are better for fields that have stumps, trees or other obstructions. The grass may be cut close up to the obstruction; then the cutter bar is quickly raised to a vertical position and lowered again when the obstruction is passed.

The foot lever (Fig. 172*b*) is also used to lift the cutter bar off the ground. It does not lift as high as the hand lever, but is used while the mower is in operation to lift the bar over stones or obstructions, or when turning corners. As there is no latch on the foot lever to keep the cutter bar raised, the operator must hold the lever down. Releasing the pressure allows the cutter bar to drop to the ground.

The lifting action of both the foot lever and the hand lever is assisted by a lifting spring. This is adjustable and should be set so that the cutter bar rests lightly on the ground. The proper setting of the lifting spring greatly reduces the friction between the cutter bar and the ground, and this in turn lessens the draft of the mower.

The tilting lever (Fig. 172*c*) regulates the angle between the cutter bar and the ground. It may be set so that the guard points are inclined upward, parallel with the ground, or inclined downward. This setting determines how short the grass will be cut. Tilting the guard points downward, for instance, would cause the grass to be cut off very near the ground. Under ordinary conditions, however, the cutter bar should be kept level, and the height of cut regulated by the adjustable soles under the inner and outer shoes.

Hinge or Yoke (Fig. 171). A large casting called the hinge, or yoke, is connected to the inner shoe of the cutting bar by heavy pins. Two coupling bars (Fig. 171) connect the hinge to the mower frame. The rear bar is called the *pushbar* because it pushes the cutter bar by means of its connection to the hinge. The front coupling bar (called the *dragbar*) is adjustable in length. The purpose and proper method of adjusting is discussed in Job 13.

Eveners. Wooden eveners are used on horse-drawn mowers. They are carried on the underside of the pole with a draft bracket which is bolted to the pole. A draft rod connects the draft bracket to the hinge applying the power directly to the cutter bar.

Levers for Tractor Mowers. Similar controls are provided for tractor mowers, both on the full-mounted and semi-mounted types. (See Fig. 173.)

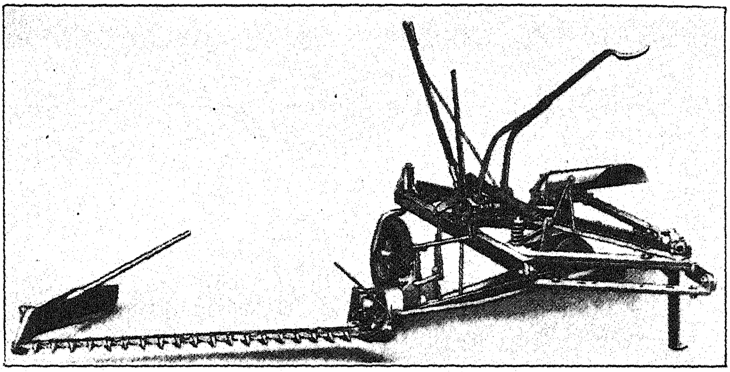


FIG. 173. Trailed tractor mower.

Industrial and highway models are required to cut along steep embankments with the cutter bar in the up or down

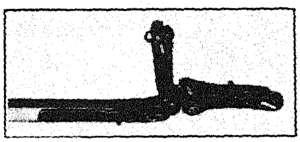


FIG. 174. Highway type of pitman with pivoted toggle arm.

position. The pitman is provided with a pivoted toggle arm which rocks on the short shaft and gives the same length of stroke to the knife, regardless of the angularity of the cutter bars. (See Fig. 174.)

JOB 13

TO ALIGN THE CUTTER BAR AND REGISTER THE SICKLE

1. Lower the cutter bar and have the mower frame in its working position. Elevate the front end of the pole 32 inches on horse-drawn mowers.

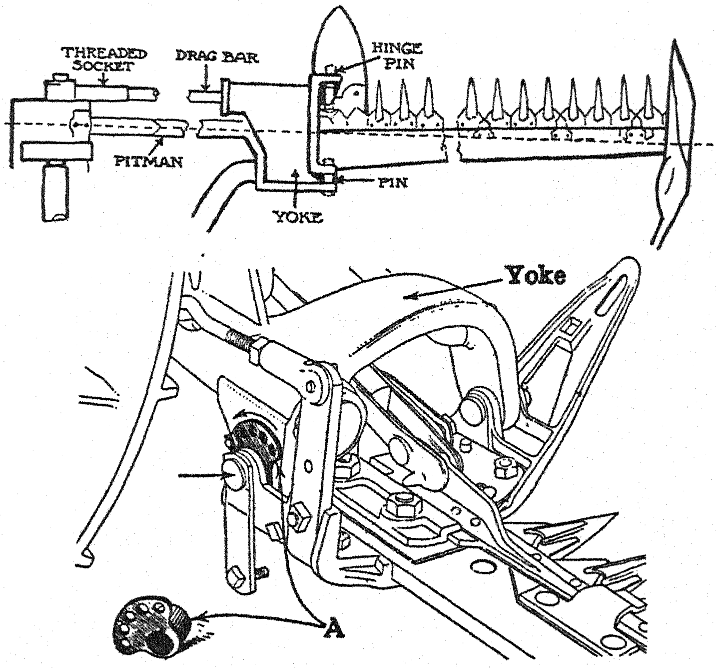


FIG. 175. *Upper*—Aligning the cutter bar. *Lower*—Eccentric bushing (*A*) used for aligning.

2. Check the alignment. Establish a straight base line through the center of the pitman and extend it beyond the outer end of the cutter bar. (See Fig. 175.) This may be done with a string. The string should be taut and should lie straight down the center of the pitman. Pull the outer end of

the cutter bar back to take up all looseness. Field operation forces the outer end to sag back.

The outer end of the knife should be about 1¼ inches ahead of the inner end. To measure the amount of lead, gauge the position of the back of the knife with relation to the string at both the inner and outer ends of the cutter bar. The outer end of the knife should lead the inner end by 1¼ inches for a 5-foot knife, and approximately 1¾ inches for a 7-foot knife.

3. Replace worn hinge pins. (See Fig. 171.) Worn hinge pins are a common cause of misalignment; they permit the outer end to sag back. Inspect the dragbar and the pushbar also to determine whether they are straight. If either one has been bent from striking obstructions, it will cause misalignment.

4. Tighten or replace the bolts holding the cutter bar to the inner shoe. Wear at these connections often causes misalignment.

5. Square the pitman with the main axle of the mower by adjusting the length of the pushbar (Fig. 171). In some makes the pushbar has a threaded adjustment for squaring the pitman. If not, it may be possible to insert washers to take up wear and force the yoke ahead to its original position.

6. Adjust the lead of the cutter bar. Several methods for forcing the outer end of the bar ahead are used:

(*a*) No special provision is made in older mowers. All that can be done is to carry out the instructions given in steps 3 and 4 above.

(*b*) To align the bar on the center-mounted tractor mower (Fig. 176), first square the pitman bar with the tractor frame by adjusting the pullbar and the dragbar. To obtain more lead, a serrated connection is provided at the front hinge pin of the inner shoe.

(*c*) Most designs employ an eccentric bushing on the rear hinge pin of the inner shoe. Disconnecting the locking bolt and turning the bushing in the direction indicated will move the outer end of the cutter bar forward (see Fig. 175).

If this adjustment is wrong, the draft of the mower is greatly increased. When the mower is in operation, the pitman and sickle should form a straight line. If the sickle lags back, it binds and the draft becomes very heavy. The pressure of the grass and ground forces the cutter bar back at the outer end when the mower is cutting. Hence, the lead given the outer end results in the cutter bar's being forced back into the true line when the machine is in operation.

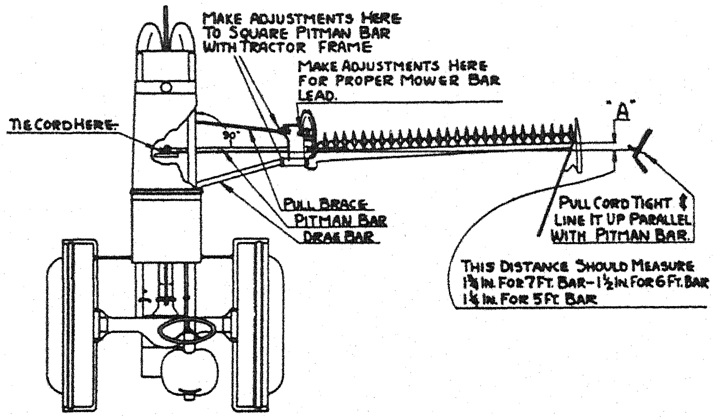


FIG. 176. Aligning the cutter bar of a tractor mower.

7. Register (or center) the sickle. When properly centered or registered, the sickle sections will be exactly in the center of the guards at the end of each stroke. If not centered, the full shearing effect of both sides of the sections cannot be obtained and cutting will not be efficiently done. (See Fig. 177.)

(*a*) See that all connections between crank wheel and sickle head are tight. With the mower in its working position, turn the crank wheel until the sickle is at either end of its stroke. Note the relative position of the sickle sections and guards. If not in proper register, the cutter bar must be moved in or out as required, to make the guards center with the sections.

(*b*) In the tractor mower (Fig. 176), center the sickle by means of the nuts and set collars on the dragbar and pull brace.

(*c*) The method shown in Fig. 177 provides shims which may easily be changed as required to shift the hinge in its coupling to the dragbar and pushbar and to move it in or out as desired.

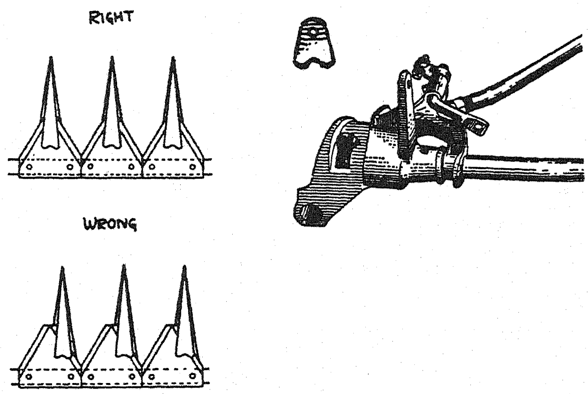


FIG. 177. *Left*—Correct and incorrect register of sickle. *Right*—Shims used for registering.

(*d*) On horse-drawn mowers re-centering the sickle usually requires adjustment of the dragbar, which has a threaded connection at its crank-wheel end, and of the pushbar where it connects to the yoke or hinge. The purpose of adjusting these bars is to move the yoke, and the cutter bar, in or out as required.

The dragbar may be shortened or lengthened, as required, by means of its threaded connection. The rear coupling bar (pushbar) may be adjusted by placing spacing washers on either side of the connection between the bar and the hinge. The effect of these adjustments is to move the hinge toward or away from the crank wheel, whichever is required to make the sickle register properly.

JOB 14

TO REPAIR A MOWER

1. Get a report from the owner or operator as suggested in previous repair jobs. Secure the appropriate instruction book and a list of repair parts.

2. Test and inspect all parts. Clean all parts, washing out gear cases and bearing retainers with kerosene or other grease solvent. Test all bearings of the main axle, countershaft and crank shaft, oil seals, the condition and adjustment of the gears—pawls and ratchets on ground-driven mowers—power-transmitting parts, crank wheel and pin, pitman box, pitman and pitman straps, and all parts of the cutting mechanism.

3. List repair operations needed.

4. Order repair parts required.

5. Replace main axle bearings if necessary. These are usually non-adjustable roller bearings. Oil seals, if used, should also be examined and renewed if necessary.

6. Replace worn pawls and springs on ground-driven mowers. Worn pawls and springs cause lost motion, resulting in "skips" in the field.

7. Test and adjust countershaft bearings. Renew them if necessary. Good countershaft bearings are essential. They control the alignment of the spur pinion with the main spur gear, and the bevel gear with the bevel pinion, and also affect the proper functioning of the clutch.

8. Adjust the mesh of the bevel gears. (See Fig. 166.) A special adjustment and thrust bearing is provided on the countershaft to resist the thrust and take up wear. By means of this adjustment, the bevel gear and pinion may be restored to proper mesh.

9. Replace gears and pinions if necessary. Examine the main spur gear and spur pinion. Replace them if the teeth are badly worn. Sometimes the teeth of these gears become worn almost to a point. This causes incorrect contact and, when the

mower is used in heavy grass, the teeth may slip past each other and break.

10. Test and repair crank-shaft bearings. These bearings, or bushings, are usually non-adjustable and must be replaced if badly worn. Excessive looseness in the crank-shaft bearings will allow the bevel gears to wear quickly, and may even result in their getting out of mesh and skipping. A worn bearing on the lower end of the crank shaft may prevent the sickle from registering properly and cause noisy and inefficient operation.

11. Repair and adjust clutch and spring. Test the action of the clutch and clutch spring; replace both if necessary. In some makes the spring tension may be increased by adjusting a set collar. On vertical-lift mowers, test the action of the lifting mechanism and clutch throwout. Lifting the cutter bar should disengage the clutch as the bar approaches a vertical position.

12. Examine the wrist pin (crank pin). This is also non-adjustable and should be replaced if it is out of round and if the sickle is to be centered accurately. The head of the wrist pin is usually riveted on the back of the crank wheel and must be filed or ground off. The wrist pin can then be punched out of the crank wheel and a new one inserted.

13. Examine the pitman for cracks or splits, pitman box, and inner and outer pitman straps. Tighten these connections with the bolts provided and then test for wear. The outer pitman straps connect to the ball of the knife head. All of these parts move rapidly; they are not enclosed, and adequate lubrication is difficult, especially on sandy, gritty soils. Any or all of the parts may require replacement.

14. Recondition the cutter bar and knife.

(*a*) Disconnect the pitman bolt (Fig. 167*B*), release pitman, remove the knife by drawing it out toward the crank wheel.

(*b*) Remove the broken sections from the sickle. The most satisfactory method of doing this is to set the edge of the sickle bar on a block of iron, with the sections extending

downward. Strike the back of the section a heavy blow at a point directly above the rivet. This will shear off the rivets and the section will drop off. The rivets may then be easily punched out of the holes in the sickle bar.

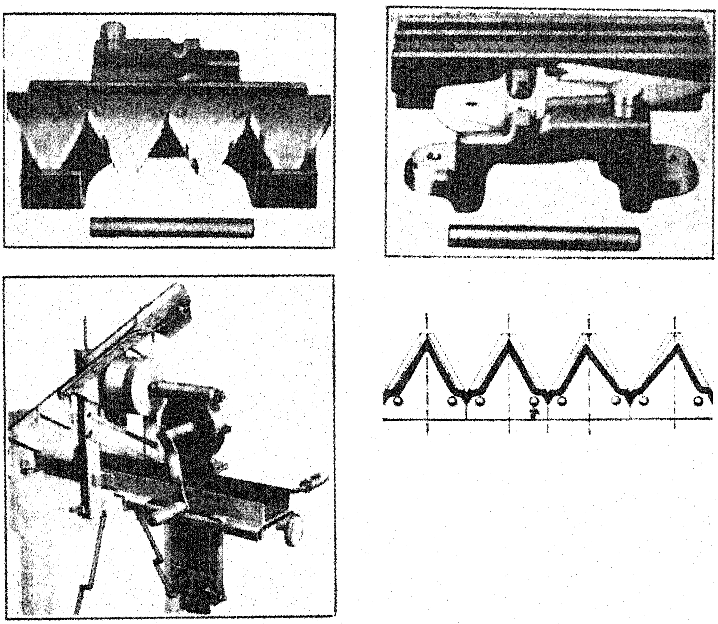


FIG. 178. Section and guard repair anvils. Sickle grinder. Correctly and incorrectly ground sections.

Put the new sickle sections in place and rivet them securely. Be sure to use rivets of the proper length and thickness. They should be large enough to fill completely the holes in the section and in the sickle bar.

A special anvil (Fig. 178) may be secured from the manufacturer, which facilitates work on many parts of the cutting mechanism, especially for removing and replacing sections, guard plates, etc.

(c) Grind the sickle section on the grindstone or wheel,

being careful to preserve the original shape and bevel. A common error in grinding sections is to grind too much away from the point, and not enough from the heel.

Special grinding wheels for sickle grinding may be secured from the manufacturer of the mower. Better work can be done with these than with the grindstone. The work can be done accurately and rapidly. Hand- or electric-driven units are available.

Correctly ground sections, as well as common errors in grinding are shown in Fig. 178. Care is necessary in using high-speed machines to prevent burning the thin, hard steel sections and to preserve the original angle and bevel.

(*d*) Replace worn guard (ledger) plates. The sharp, serrated edges of the guard plates are as vital to good cutting as the sections. Examine each one and replace any that are rounded (worn) or broken. Each is held in the guard with one rivet. Remove the guard, file off the end of the rivet on the bottom side of the guard and punch the rivet out through the upper side. If a repair anvil is available, guards need not be removed. Place the anvil beneath the guard and punch the rivet down and out the bottom of the guard. Start the rivet with a heavy punch of the same size as the rivet; follow through with a punch of slightly smaller diameter than the hole in the guard plate. Clean the guard, fit the new plate carefully, and rivet securely.

(*e*) Replace wearing plates (Fig. 169*d*) and sickle clips (*c*). If the sickle clips are not too badly worn, striking them with a hammer will bend them downward so that they will hold the sickle down properly against the wearing plates. (Sickle should be removed.) A slight clearance (about $1/64$ inch) is desirable between the sickle and the sickle clips. Defective wearing plates and worn knife clips prevent a good contact between the section and the guard plate. The correct condition is indicated in Fig. 170. The slotted holes in the wearing plates provide adjustment to compensate for

wear on the rear of the knife back (to which the sections are riveted).

(*f*) Align the guards. It is important that all guard plates be in the same level plane so that the sickle sections may make contact with them equally all along the cutter bar. If one guard is high, it will prevent good shear contact at several adjacent guards. Lay a thin, metal straightedge on the guard plates to detect any that are out of alignment. Force high guards down into alignment by striking them just ahead of the guard plate.

(*g*) Adjust knife-head guides, at the inner end of the cutter bar, so that the knife runs free, with but only a slight vertical ply, not exceeding $\frac{1}{64}$ inch. Excessive vertical movement of the inner end of the knife will cause breakage.

15. Inspect the inner and outer shoe soles. These are adjustable to regulate the height of cut and support the cutter bar during field operation. If badly worn replace them, or repair by adding extra metal with the welding torch. Check the connection between the swath board and outer shoe and between the grass stick and swath board.

16. Take up the end play in the main axle with the take-up washers provided (Fig. 164*c*).

17. Align the cutter bar and register the sickle (Job 12).

18. Paint all parts as required. Cover the sickles with oil or grease and store them safely.

Operating a Mower

Lubrication. Provision for lubrication varies in the different makes; some makes employ large reservoirs containing a lubricant for many parts, whereas others require the separate lubrication of each working part. Oil reservoirs form a part of the main frame and contain a level plug, or other part, for gauging the quantity of lubricant.

Under most conditions the following parts require lubrication; but, on sandy and gritty fields, lubrication of the pitman

pivot straps, sickle head, sickle, and other exposed parts is not beneficial because the resulting accumulation of abrasive material will increase wear. Such parts are: crank shaft bearings (2); countershaft bearings (2); pitman strap bearings (2), one at each end of the pitman; main axle bearings; main wheel hubs; clutch-shifting parts; inner-shoe pins; joints of lifting mechanism; levers and pivots; and wearing plates.

Speed. Most tractor mowers can be operated at a speed of 3½ to 4 miles per hour if field conditions permit. The speed of the cutting mechanism has a constant ratio to the engine speed. Hence, for heavy cutting or adverse conditions, a lower forward speed may be selected to increase the sickle strokes per foot of travel.

Planning the Field. Various plans are followed but they are all similar in that mowing is done by driving around the field, not back and forth as with the plow or harrow. The field is started at one corner and the mower is driven clear around, following the boundary at each edge of the field. Each succeeding swath is nearer the center of the field.

It is sometimes necessary to drive the horses or the tractor through the standing grass when making the first round. The grass that is thus left standing may be cut later, by driving around the field in the opposite direction.

Raise the cutter bar with the foot lever at the corners. The mower is run straight down one edge of the field until the cutter bar completes its swath. It is backed or the tractor is turned so that the sickle will enter full width into the grass of the next edge of the field. Then the foot lever is released and the cutter bar dropped again.

Some difficulty is experienced in turning at the corners of the field. The swath cut at the corner must be the same width as that in any other part of the field.

The clutch should be engaged before driving the mower into the grass. The sickle should always be moving before entering the grass, otherwise it may become clogged up.

Several methods of turning at the corners with tractor mowers are illustrated in Fig. 179.

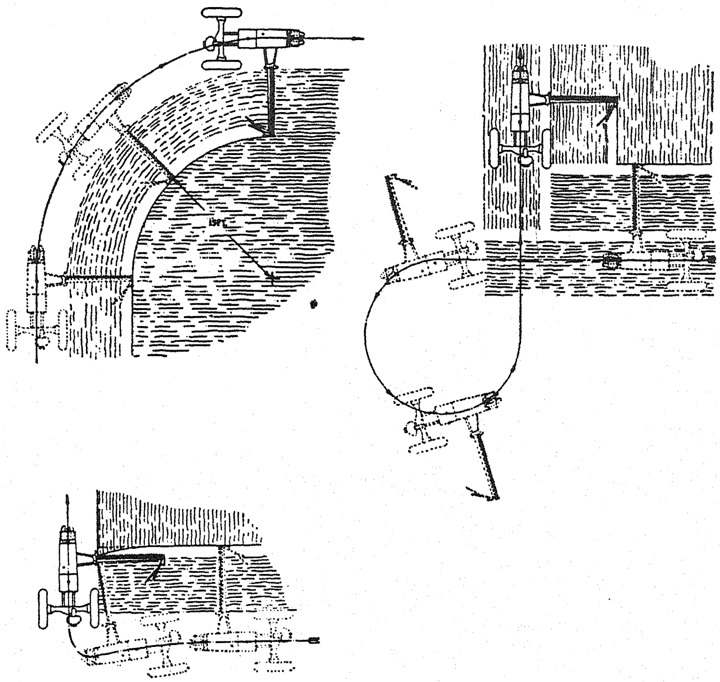


FIG. 179. Three methods of turning corners with tractor mowers.

Field Adjustments. *Levers.* The tilting lever tilts the cutter bar forward for cutting very short grass. This should be done only on fields that are known to be free from obstructions; otherwise, the knife and guards may be broken or damaged. For this reason it is desirable to have the guards tilted upward when working on rough ground.

The foot lever is used to raise the cutter bar a short distance above the ground. When passing over stones, roots, or other obstacles that do not project high above the ground, the foot lever alone is used.

The large lifting lever is used to raise the cutter bar high above the ground. This is necessary in order to pass over high obstacles. Raising the bar with this lever disengages the clutch. The action of the foot lever alone does not disengage the clutch. The lifting spring should be adjusted so that the bar can be easily lifted with either lever.

Lifting Spring. There should be sufficient tension to make lifting the bar easy, but if the tension is too great the bar will not follow the contour of the ground or, when raised to pass an obstruction, it will not return quickly to its working position. Proper adjustment of the lifting spring lessens the weight on the shoe soles and transfers most of the weight of the bar on the wheels or tractor. The cutter bar should practically float over the ground.

Clutch. The clutch lever should be adjusted to give full engagement and disengagement to the driving and driven parts of the clutch. On vertical-lift mowers disengagement should take place automatically as the bar is lifted. Do not engage the clutch of a tractor mower with the engine running at high speed. Do not operate the power take-off mower without a shield over the power take-off shaft.

Height of Cut. Raise or lower the inner and the outer shoe soles to give desired cutting. High cutting attachments, especially for highway work, may be secured. Do not use the tilting lever alone for regulating height of cut.

Gag Lever Links. Be sure to adjust with the turnbuckle so that the outer end of the bar lifts before the inner end. Shorten this connection to make the outer end of the bar lift faster. Be sure that the adjustment is secured to the adjustment with the locknut.

Level Cutter Bar. The cutter bar should run level and square on the shoes. To obtain this setting, the pole on horse-drawn mowers should be about 32 inches high at the neckyoke. This height also gives the correct working angle to the frame. A similar adjustment is possible on the mounting of tractor mowers.

Grass Board and Stick. The grass board is usually left slightly loose so that its underside follows the contour of the ground but, if desired, it may be rigidly set. The grass stick should be set so that it lays the cut grass well to the left of the outer end of the cutter bar. This allows the horses or the tractor to straddle the cut swath the next time around. The near end of the stick should be raised for cutting tall grass and lowered for cutting short grass.

Field Troubles

The mower cannot be operated to advantage when the grass is too wet. The wet grass has a tendency to clog the sickle and also may cause the drive wheels to slip.

Under normal conditions, however, the mower gives very little trouble. The various troubles that do occur are nearly always caused by a wrong adjustment or worn parts.

The most common troubles, with their causes and remedies, are listed below.

Sickle Stops and Drive Wheels Slide. This may be caused by any one of the following conditions:

(*a*) Some obstruction may be stuck in the sickle or else grass may be wedged between the sickle and guard plates.

(*b*) Guards out of alignment (bent from striking obstruction).

(*c*) Sickle may be clogged owing to the operator's starting the mower in heavy grass. The sickle should be in motion before entering the grass.

(*d*) Worn pawls causing lost motion, which allows the sickle to be idle for an instant when the mower is started. The grass wedges in the stationary sickle.

The above troubles may be remedied by replacing worn parts, correcting the alignment of the guards, or adjusting the sickle clips properly.

Pitman Box Heats and Knocks. This is usually caused by inadequate lubrication, resulting in a worn bearing. The large space thus left between the wrist pin and the bearing allows all the lubrication to leak out, and heating results. The pitman box should be replaced.

Cutter Bar Jumps or Rises Frequently. This is caused by the lifting spring's being too tight. Loosen the spring so that the bar rests more heavily on the ground.

Sickle Does Not Start with Drive Wheels. (Wheels turn part of a revolution before the sickle begins to move.) This condition should be remedied at once or else it will give constant annoyance.

It may be caused by any one of the following conditions:

(*a*) Worn pawls, ratchets, or pawl springs.
(*b*) Worn bearing on the countershaft or crank shaft.
(*c*) Worn gears on the countershaft or crank shaft.
(*d*) Worn clutch.
(*e*) Worn connection between the pitman and sickle head.
(*f*) Slip clutch loose or worn (on tractor mowers).
(*g*) Loose drive chain or belt (on tractor mowers).

Knife Breaks. Usually the breakage occurs near the knife head. It is caused by worn knife clips, guides, and wearing plates. The looseness, due to wear, permits the knife to bend up and down slightly in its stroke, which finally causes breakage. Breakage is also caused by the guards' being out of line, or loose, loose sections, worn knife head, pitman and knife connections too loose or too tight, and misalignment of the cutter bar.

Ragged Cutting. This is caused by a dull knife, guards' being out of line, dull or broken guard plates, a knife not centered, loose sections, worn knife-head guides, and uneven adjustment of the shoe soles.

Heavy Draft. The most common causes are a lagging cutter bar; the lack of lubrication; a binding, knife-lifting spring which is too loose; a dull knife; a knife not centered.

Pitman Breaks. The pitman breaks and the rivets in the pitman straps loosen. This is caused by wear in any of the pitman connections between the wrist pin and the knife head. Looseness increases the hammering effect of the reciprocation of the pitman.

Pitman breakage may also be caused by folding the cutter bar for transportation without first placing the crank wheel at its highest or lowest point.

SPECIAL EQUIPMENT

Windrow Attachments. The type illustrated in Fig. 180 is used for canning peas and is designed to deliver the row at

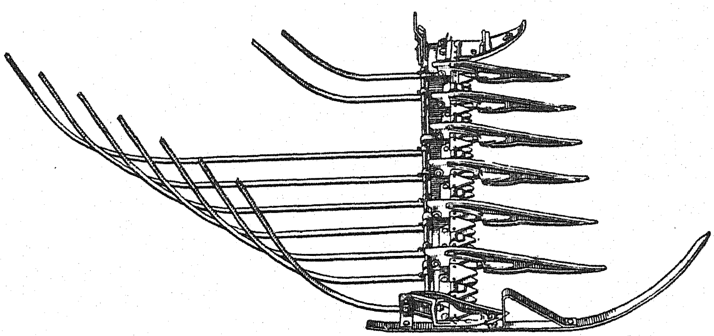


FIG. 180. Center-delivery windrow attachment, with lifting guards, stub guards, and outside divider.

the center of the cutter bar. Various other types are available; some are designed to deliver the row at the inner end of the bar, such as that designed for harvesting green hay crops for silage.

High-cut Attachment. This is designed to permit cutting from 3 to 12 inches above the ground. It is composed of a supporting wheel or runner for the outer shoe and a holdup hook or link for the inner end of the cutter bar. It is useful for cutting weeds, topping alfalfa and clover, cutting vines and grass before digging potatoes, etc.

Lespedeza Bar. Guards are spaced 1½ inches apart and have no ledger plates. A special knife with serrated sections may be secured and the design permits close cutting (as low as 1½ inches) of special grass crops and grass on lawns, golf courses, fairways, etc.

Brush and Weed Bar. Furnished with smooth ledger plates, these heavy, steel guards are used for weed-cutting on highways and also for light brush. The guards have no lips, and

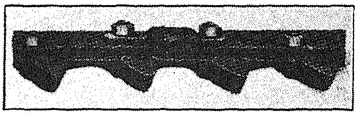


FIG. 181. Brush and weed bar.

so when cutting heavy materials choking and clogging are lessened (Fig. 181).

Heavy-duty Bar. Extra heavy and fitted with special guards with broad contact bases, this equipment is used for stony, rough cutting conditions.

Steel Pitman. A forged steel pitman can be secured for some makes, and is adapted for use in rough work, as it can easily be straightened if it becomes bent.

Buncher Attachment. The cut crop falls on to the fingers and it is retained until the operator raises the gate with a foot lever delivering it in a bunch. It is used for cutting seed clover, soybeans and similar crops.

Reaping Attachment. This is used for cutting small fields of grain and grass seed crops. An extra seat is provided, from which the second operator can rake off the cuttings in bunches.

CHAPTER VII

GRAIN BINDERS

The grain binder is one of the most intricate of all farm implements. Considering the variety of operations performed, adaptability to different field conditions, and the rapid rate

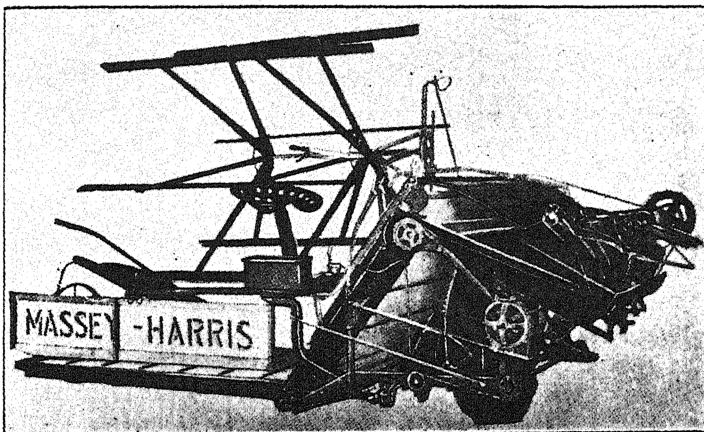


FIG. 182. Horse-drawn grain binder.

at which the work is accomplished, the grain binder presents an excellent example of engineering ability and manufacturing efficiency.

The harvesting operation includes cutting the standing grain, binding the cut grain into compact bundles, and dropping the bundles in rows (called windrows) across the field.

The accomplishment of this three-fold function requires many mechanical adjustments on the binder, discussed in detail in this chapter. Some of the varying conditions necessitating a wide range of adjustments are as follows:

1. Topography of the field: hills, gullies, etc.
2. Very short or very tall grain.
3. Lodged or tangled grain.
4. Heavy or light grain.
5. Green, ripe, or overripe grain.

Types and Sizes

Horse-drawn Binders. The width of cut designates the size. The common sizes of horse-drawn binders are 6-, 7-, and 8-foot cuts. The 6-foot machine can be drawn by two horses in light cutting, but is usually equipped for three horses. The 7-foot size is furnished with a three- or four-horse evener, and the 8-foot with a four- or five-horse evener.

The weight of a 6-foot machine with tongue truck is approximately 2000 pounds, and an 8-foot size with tongue truck weighs approximately 2200 pounds.

Tractor Binders. 1. *Stub-pole Tractor Hitch.* Binders that are built to be drawn by horses can very easily be oper-

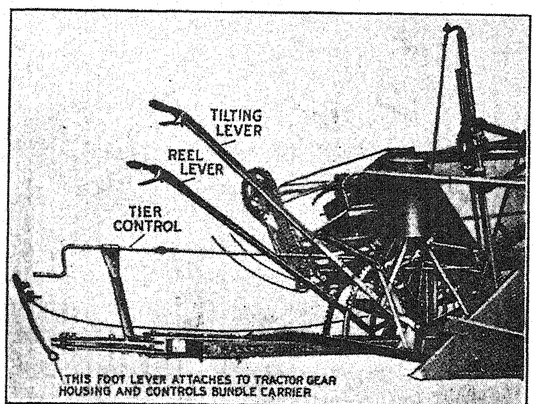


FIG. 183. One-man-control tractor hitch.

ated with tractors. A short pole can be connected from the binder to the drawbar of the tractor. Such combinations re-

quire two men to operate them, one man to drive the tractor and another to operate the binder.

2. *One-man Control Hitch* (Fig. 183). To do away with the necessity for the extra man, special tractor-binder control hitches have been designed. These make possible the control of the binder from the seat of the tractor as all levers and controls are within reach from the tractor seat.

3. *Power-driven Tractor Binders* (Fig. 188). Special tractor binders are built in 8- to 10-foot sizes. These are suitable for use with medium-sized farm tractors. The power for driving tractor binders is taken directly from the tractor. No chain is used on the main wheel of the binder as is done in horse-drawn binders. A special shaft mounted in the binder frame receives power from the power take-off of the tractor and transmits it to the binder mechanisms. (See p. 257.)

All the levers are mounted within easy reach of the tractor seat. The bundle carrier is operated by a trip rope.

Tractor binders are designed for one man or two man operation. The construction of tractor models varies from the horse-drawn, chiefly in the method of applying the power and the location of the controls. Certain parts also operate faster as they must handle more grain, due to the wider swath cut by the tractor binder.

Construction and Principal Parts

(*Ground-driven Type*)

Main Frame (Fig. 184). The main frame is made of flat or angle steel bars which are riveted together and well braced. They form a rectangle with the inner ends projecting. These ends are bolted to the binder platform.

A bracket is bolted to the frame, at each side of the main wheel. A third bracket for connecting the tongue is bolted to the front of the frame.

Bearings for the countershaft and the crank shaft are carried in the main frame. Two roller bearings are provided for the

countershaft, and two roller bearings for the crank shaft. The two countershaft bearings and one of the crank-shaft bearings are shown in Fig. 185.

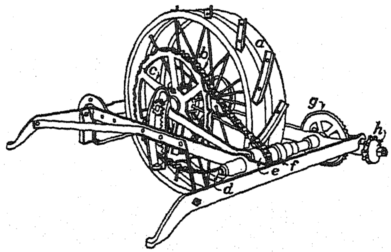


FIG. 184. Main frame, main wheel, and main chain.

Main Wheel. The main wheel carries the greater part of the weight of the machine and acts as a drive wheel to furnish power for all of the moving parts. The rim of the wheel carries lugs so that good traction can be secured. The main wheel is mounted on a short axle carried on two roller bearings. A removable sleeve slips through the center of the wheel hub and revolves on the roller bearings. A small pinion is keyed to each end of the main-wheel axle. This fixes the axle in the brackets. The axle is stationary and the wheel revolves on it. By means of a raising-crank worm and worm gear the axle may be raised or lowered in the brackets. This regulates the height at which the grain is cut.

A large sprocket is bolted to the hub of the wheel. The driving power for all of the working parts is transmitted by this main sprocket.

Main Chain (Fig. 184). A large chain transmits the power from the main-wheel sprocket to the clutch sprocket which is carried on the countershaft. A tightener is provided to keep the chain at proper tension.

Transmission of Power to the Sickle. The various parts which transmit the power to the sickle are quite similar in con-

struction and function to those used in mowers. Hence the description will not be repeated here. These parts are as follows:

(*a*) *Main-wheel Sprocket.*

(*b*) *Main-drive Chain.*

(*c*) *Clutch and Clutch Sprocket* (Fig. 185). The clutch and sprocket are located on the countershaft. A clutch-shifting fork is connected to the clutch by means of a rod located near the operator's seat. Turning this rod slides the clutch along the shaft and allows the notches to come out of en-

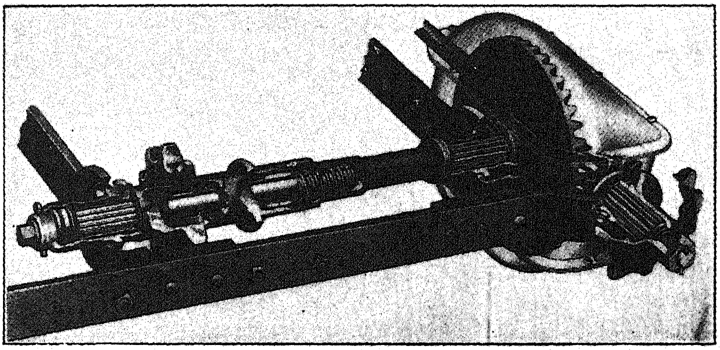


FIG. 185. Clutch sprocket, countershaft bevel gear, and pinions.

gagement. The clutch sprocket revolves freely upon the countershaft and does not drive it unless the clutch is engaged. A large coil spring holds the clutch in engagement.

(*d*) *Countershaft and Bearings* (Fig. 185). An adjustment is provided on the countershaft for taking up wear in the bevel gears.

(*e*) *Bevel Pinion and Bevel Gear* (Fig. 185). As in the mower, these gears change the direction of the motion, the crank shaft being placed at a right angle with the countershaft. The large bevel gear is keyed to the countershaft and the small bevel pinion is keyed to the crank shaft. These gears are enclosed in an oil-tight housing and run in a bath of oil.

The crank-shaft sprocket is keyed to the rear of the crank shaft and transmits power to various parts of the binding mechanism and the platform and elevator aprons.

(*f*) *Crank and Wrist Pin* (Fig. 186). The crank (*a*) is keyed to the front end of the crank shaft. It carries the

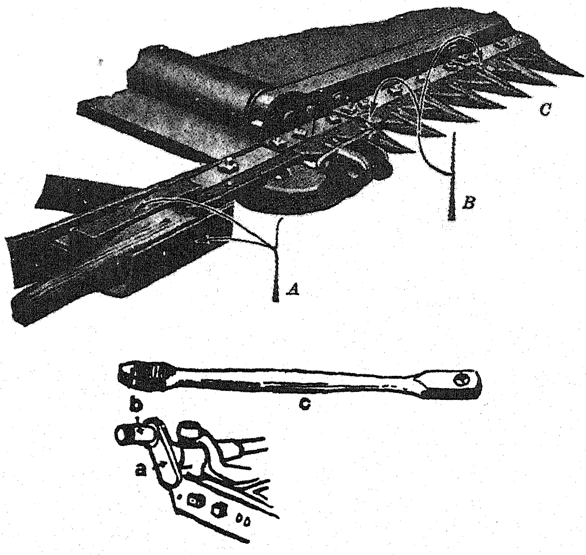


FIG. 186. *Upper*—Connection of pitman to sickle. *Lower*—Crank (*a*), wrist pin (*b*), and pitman (*c*).

wrist pin (*b*) to which the pitman (*c*) is attached. A crank wheel, similar to that used in mowers, is used on some makes of grain binders.

(*g*) *Pitman.* The pitman may be made of wood or steel, wooden pitmans being the more commonly used. Wood is light and resilient. The pitman is held in place on the wrist pin by a latch or nut. It may be easily removed when it is necessary to change the knife.

The opposite end of the pitman slips over the stud in the end of the sickle head and is held in place by a steel guide.

Transmission of Power (Power Take-off Drive). The power take-off shaft of the tractor is extended by means of square telescoping shafts and universal joints (Fig. 187) and

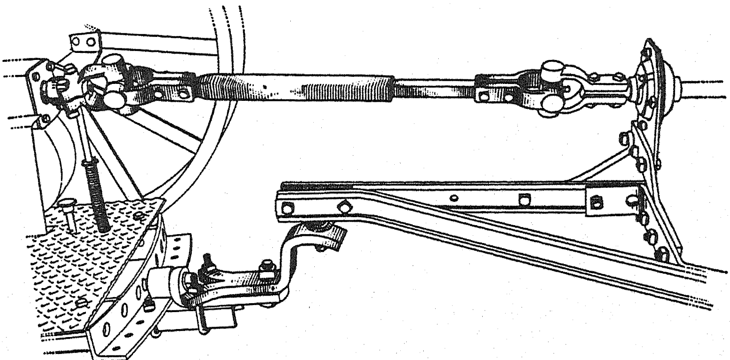


FIG. 187. Hitch and power take-off drive for tractor binder (shield removed).

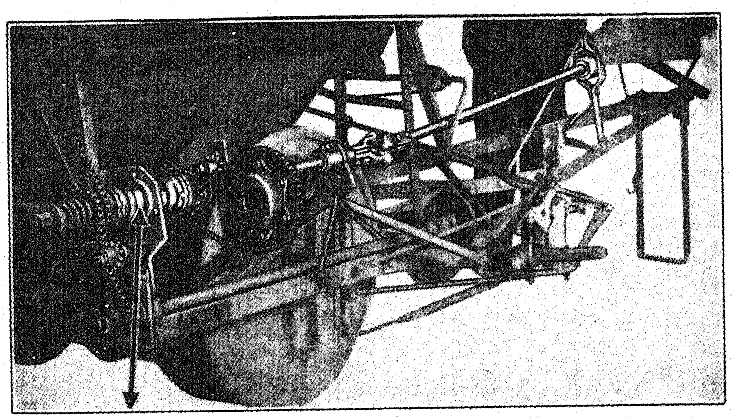


FIG. 188. Power take-off drive for tractor binder.

is applied to the mechanism of the tractor. The main wheel of the binder, in this case, is only a transport wheel.

The drive shaft from the tractor may be connected directly to the crank shaft of the binder. The stub pole of the binder is

connected to the regular tractor drawbar in the same way as any trailed implement.

Another design of power drive (Fig. 188) extends the drive shaft through to the rear of the tractor. Three steel roller chains are driven by it, one driving the binding attachment, another driving the crank shaft and sickle, and the third driving the aprons.

Cutter Bar (Fig. 186). The construction of the cutter bar is similar to that of the mower. The guards, guard plates, sickle clips, and wearing plates are attached in the same manner and have the same functions as corresponding parts of the mower.

The cutter bar of the binder, however, does not touch the ground. The weight is borne on the wheels. There is no tendency for the outer end of the cutter bar to lag behind; hence no provision for aligning the cutter bar is necessary.

The bar is made of heavy-stock Z-bar angle steel. The guards are bolted to the cutter bar. They are spaced 3 inches apart, as in mowers. A 7-foot binder, therefore, has twenty-eight guards. The sickle sections are held down against the guard plates by the knife holders as in mowers.

The shape of the sections of the binder sickle is somewhat different from that of those in the mower. The regular binder section is rough or serrated. This type of section is used for cutting all kinds of grain, where the straw is always fairly dry. Smooth sections may be obtained for binder sickles in case it is necessary to use the binder for cutting grass crops.

The combination of smooth guard plates with rough or serrated knife sections gives the results in cutting grain.

The travel of the sickle is twice as far as in the mower, the knife moving from the center of one guard, entirely through the next guard and to the center of the third guard. No adjustment is provided for centering or registering the sickle.

Grain Wheel (Fig. 189). The small wheel is called the grain wheel because it runs at the side of the swath nearest

the uncut grain. It supports and is attached to the outer end of the platform. The axle for the grain wheel is cast integral with the axle slide which may be raised or lowered by the crank, thus changing the height at which the grain is cut. The adjustment of the height of the outer end of the platform is made by the grain wheel. The height of the inner end of the platform may be changed by raising the main wheel. These adjustments must be so made that the grain is cut the same

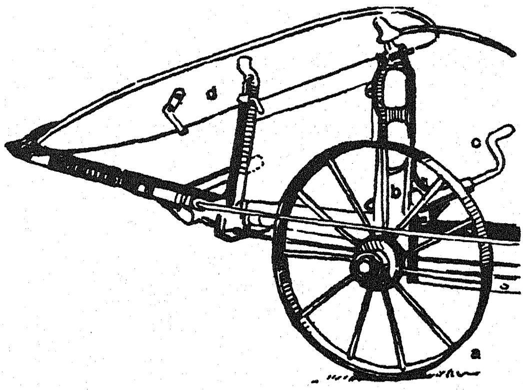


FIG. 189. Grain wheel and outside divider.

length at both ends of the platform. This usually means that the platform will be level, but on side hills one end of the platform may be lower than the other. To do even, uniform cutting, the platform must be set to conform to the slope of the ground.

The grain wheel revolves on a roller bearing, which is lubricated by means of an oil tube in the hub of the wheel.

Platform. Figure 190 shows the platform with the platform rollers in place. The cutter bar is attached to the front of the platform. As the grain is cut by the sickle it falls on the moving platform apron (Fig. 192) which conducts it to the elevator aprons.

To prevent the grain, especially very tall grain, from being

carried or blown over the rear of the platform, the platform deck (Fig. 191*a*) and the wind break or back curtain (*b*) are used. Both are adjustable. They practically enclose the rear of the platform.

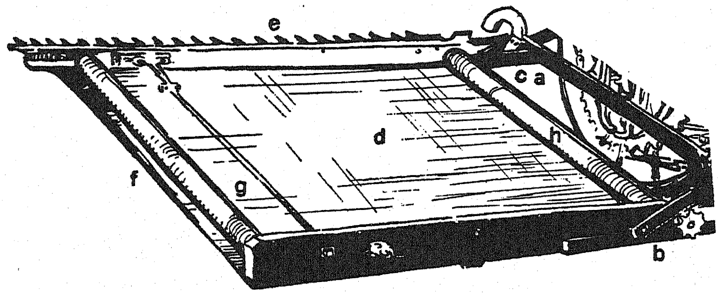


FIG. 190. Platform and platform rollers.

Figure 190 gives a view of the platform without the apron in place. Note the two platform rollers *f* and *h*. The inner roller is driven by the sprocket and this roller drives the canvas apron. The outside roller is a carrier or "idler" roller only, that is, it does not drive and only carries the canvas apron.

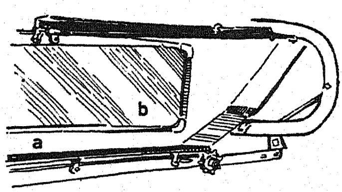


FIG. 191. Platform deck and back curtain.

The outside roller (*g*) is provided with a canvas tightener. If the aprons are not tight enough the rollers will slip inside them and the aprons will not move. As it is difficult to draw the straps on the aprons tight enough, some form of canvas tightener is usually provided for all of the aprons. The aprons must be kept tight while the binder is in operation. If the binder is left overnight or for a few hours with the aprons on, the canvas tightener for each apron should be released.

The bottom of the platform is made of sheet steel, which is carried on three or more angle-iron cross sills.

Elevators and Rollers. The elevators with their aprons receive the grain from the platform apron and carry it upward or "elevate" it to the deck where it is bound into bundles.

Figure 192 shows the placement of the rollers, the direction of travel of the elevator aprons, and the course of the grain as it travels upward between the upper and lower elevators.

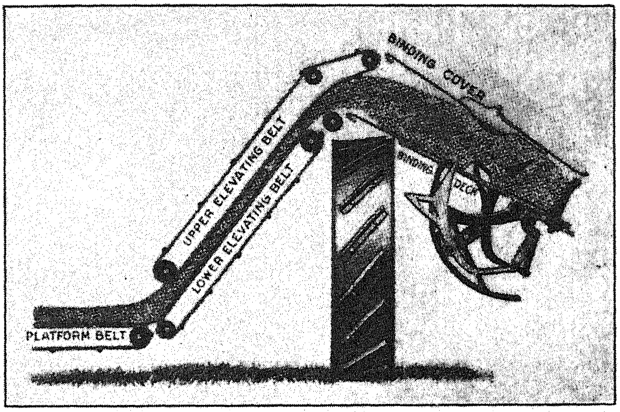


FIG. 192. Elevators and rollers.

The lower rollers of both elevators are idle rollers (not driven). They are pivoted to the elevator guides so that the lower rollers may be raised. This shortens the distance between the lower and upper rollers of the elevator. These pivoted bushings, therefore, are used as canvas tighteners. The canvas straps are drawn tight with the rollers in the loose position. Then the operator can press the rollers down firmly with his foot and they will lock in the downward position and tighten the canvases.

The rollers at the upper ends of the elevators are both driven rollers. The upper roller of the lower elevator is the main-drive roller. It is driven by the sprocket (Fig. 193*F*).

The opposite end of this roller is geared to the roller above it so that the two turn together.

The upper elevator is usually a floating one. If the grain is very heavy the upper elevator will be forced away from the lower one to allow more room between them for the passage of grain.

An additional roller called the *deck roller*, placed as shown in Fig. 192, helps deliver the grain to the deck evenly. It is driven by gears from the main-drive roller. An intermediate gear is used so that the direction of rotation of the deck roller will be the same as that of the main-drive roller.

Apron Chain (Fig. 193). One long chain, containing about one hundred links, drives both elevator aprons and platform

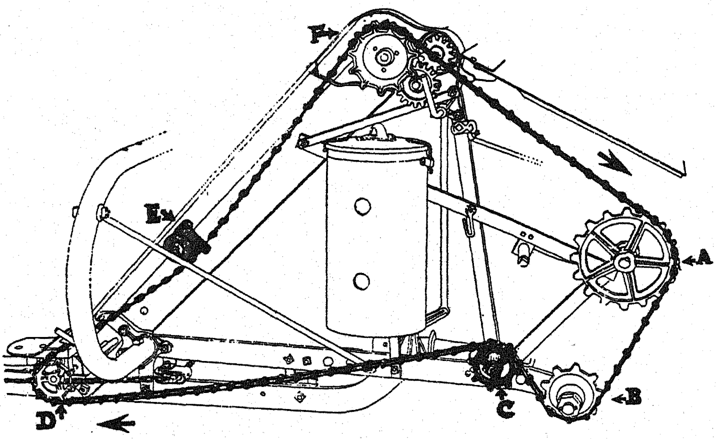


FIG. 193. Apron and binder-drive chain.

aprons. The driving power for this chain is taken from the crank-shaft sprocket (*B*). The chain then passes over the chain tightener (*C*), down to the platform roller sprocket (*D*), up and under the wooden chain tightener shown at *E*, to the main-drive roller sprocket (*F*). Then the chain passes downward over the binder-driving sprocket (*A*) and returns to the

crank-shaft sprocket. The arrows show the direction in which the chain travels. The drive illustrated is for a standard, ground-driven type; others, including tractor, power-driven binders, use a similar chain for driving the aprons.

Reel (Fig. 194). The function of the reel is to bend the standing grain toward the sickle and hold it there until after the sickle has cut it.

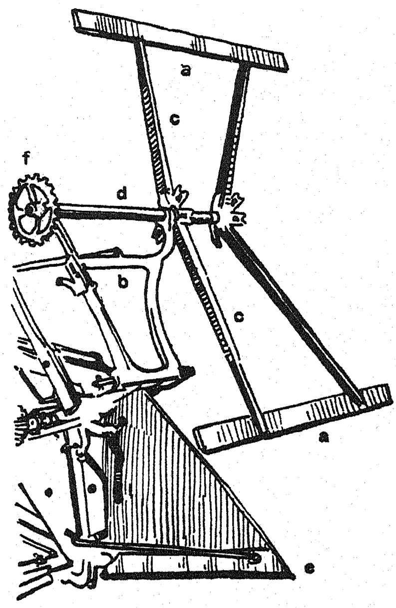


FIG. 194. Reel and inside divider.

Two levers are used to adjust the reel to the many different field conditions. One raises and lowers the reel, and the other tilts it forward or backwards. It should be adjusted so that the slats strike the standing grain just below the head. The levers are connected by rods to the reel frame (Fig. 194*b*). The placement and purpose of all of the levers of a standard type of binder are illustrated in Fig. 201.

The reel slats and reel arms (Fig. 194*a* and *c*) are bolted to the reel shaft (*d*). Six reel slats are commonly used. In binders of 7-foot cut or more, the outside end of the reel shaft is supported by a standard which is called the *outside reel support* because it is attached to the outer end of the platform.

The reel slats reach from the inside divider to the outside divider. Several holes are provided for attaching the slat to

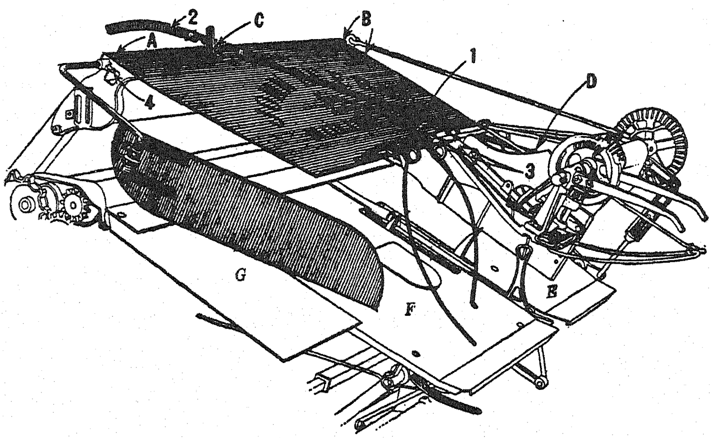


FIG. 195. Binder deck, deflector, and deck windboard.

the arm so that proper adjustment may be made to prevent the slat ends from striking against either divider.

Power for driving the reel is taken from the front end of the main-drive roller and is transmitted through spur gears and bevel gears to the reel-driving sprocket.

Inside Divider (Fig. 194*e*). The inside divider is made of sheet iron and is braced from the main frame as illustrated. Its function is to gather and direct the grain, at the inner edge of the swath, toward the sickle.

Outside Divider. The outside divider gathers and directs the grain toward the sickle at the outer edge of the swath, leaving a clear, distinct edge of uncut grain. The long, pointed

front of the divider picks up lodged or tangled grain and clears a track for the grain wheel. (See Fig. 189.)

Binder Deck (Fig. 195). The cut grain is delivered by the elevator aprons and the deck roller to the deck. Here the loose grain is packed together and bound into compact bundles.

While this operation is being performed, the grain is prevented from slipping down the inclined deck by means of the retarding springs and the trip hook (*E*).

The deck is made of wood or steel. A center section (*F*) is hinged to give access to the parts below for lubrication and adjustment.

The rear of the deck is enclosed by a small board called the *deck windboard* (*G*). This may be folded to allow more space when long straw is being cut. The deck windboard is attached as indicated (4). The deflector attached at *A* and *B* keeps the cut grain down on the deck.

Adjuster or Butter (Fig. 196). The adjuster is located at the front end of the binder deck. It is fastened by cotter pins at the points indicated by the arrows. The function of the adjuster is to even straws at the butt end so that a well-shaped bundle may be secured. This process of evening up the straws at the butt gives rise to the term *butter*. The position of the adjuster may be regulated for long or short grain by means of a long shifting rod, which passes over the deflector to a point near the operator's seat (Fig. 195 2). The inside of the adjuster is faced with triangular lugs, which aid in shaping the butts of the bundles.

Binder Attachment (Fig. 197). The various parts which pack the straw into bundles, tie the bundles, and discharge them are considered as a unit and called the *binder attachment.*

The binder attachment is mounted on the main frame. It may be shifted forward or backwards on the frame by means of the binder-shifting lever. This is necessary in order that the bundle may always be tied near the middle, regardless of the length of the straw.

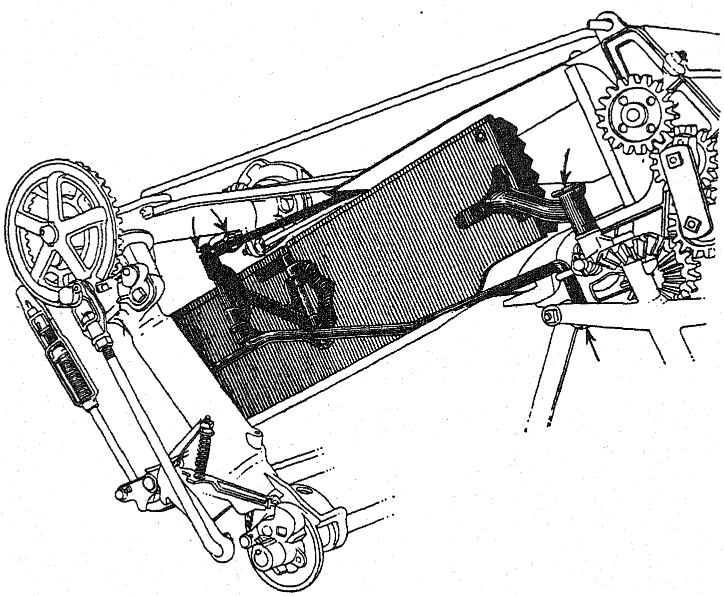


FIG. 196. Adjuster or butter.

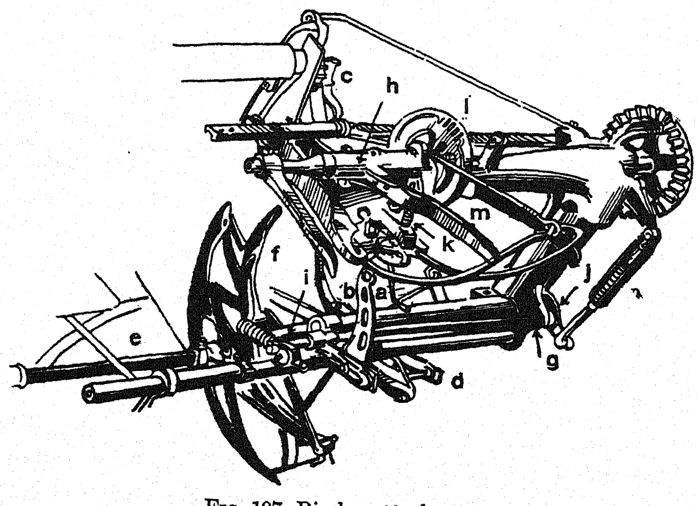


FIG. 197. Binder attachment.

1. *Binder Drive.* Figure 197*e* shows the means by which the binder attachment is driven. A square driving shaft transmits the power from the binder-driving sprocket to the packer crank.

2. *Packers and Packer Crank* (*f*). The two arms or forks shown in the illustration are called packers. The upper ends of the packers project through slots in the deck. The motion of the packers presses the grain on the deck down against the trip hook and packs it into a firm, compact bundle.

The packer shaft extends to the front end of the binder. It is, in effect, an extension of the square drive shaft shown in *e*. It transmits the driving power to the forward end of the binder attachment.

3. *Binder Attachment Shafts* (Fig. 197). There are three shafts in the binder attachment in addition to the packer shaft mentioned above:

(*a*) Needle shaft, *i*.
(*b*) Knotter shaft, *h*.
(*c*) Compressor shaft, *g*.

None of these three shafts turns steadily; they move only when a bundle is being tied and discharged; then the knotter shaft revolves, but the compressor shaft merely rocks backwards a few degrees. This slight motion unlatches the trip stop (*j*). The knotter shaft and the needle shaft are in motion only while the trip stop is unlatched.

The knotter shaft and needle shaft are enclosed in the frame of the binder attachment. The location of the needle shaft is indicated by the arrow (*i*) in Fig. 198, and the location of the knotter shaft by the arrow (*h*).

4. *Knotter* (Fig. 198). The knotter is carried at about the center of the binder attachment. It is mounted above the binder deck as indicated by the arrow in Fig. 197*K*. The knotter ties a knot in the band of twine, which is drawn around the bundle by the needle. After this knot is tied, a small knife contained within the knotter cuts the twine and the bundle is discharged.

There are three principal working parts in the knotter:

(*a*) Knotter hook (*b*).
(*b*) Twine-holding disk (*c*).
(*c*) Twine knife.

The tension of the movable hook or bill may be adjusted by the spring and setscrew shown at *e*. The method of making the correct adjustment is discussed on p. 278.

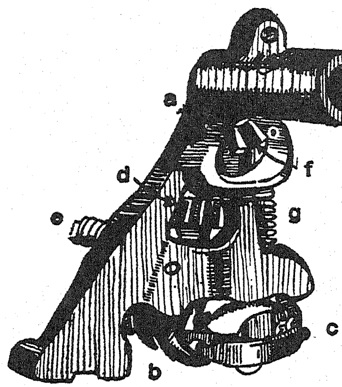


FIG. 198. Principal parts of a standard type of knotter.

The tension of the twine-holding disk is regulated by the setscrew and spring (*g*). (See directions for making correct adjustment, pp. 278-279.)

The twine knife cuts the twine after the bundle has been tied. It must be kept sharp. This is accomplished with an oilstone.

The moving parts of the knotter are driven from the knotter cam gear which is keyed to the knotter shaft. The small pinion (Fig. 198*d*) drives the knotter hook (*b*), which actually ties the knot. The small pinion (*f*) drives the twine-holding disk.

5. *Discharge Arms.* The discharge arms are mounted on the inner end of the knotter shaft (Fig. 197*h*). When the bundle is the proper size and sufficiently compressed, these arms re-

volve and throw it down from the binder deck to the bundle carrier.

6. *Trip Hook and Compressor Shaft.* The loose grain is packed against the trip hook (Fig. 197*b*) by the packers. As it accumulates, the pressure against the trip hook increases. When the proper amount of grain for a bundle has been accumulated, the pressure against the trip hook forces it back. This rocks back the compressor shaft and the trip stop is un-

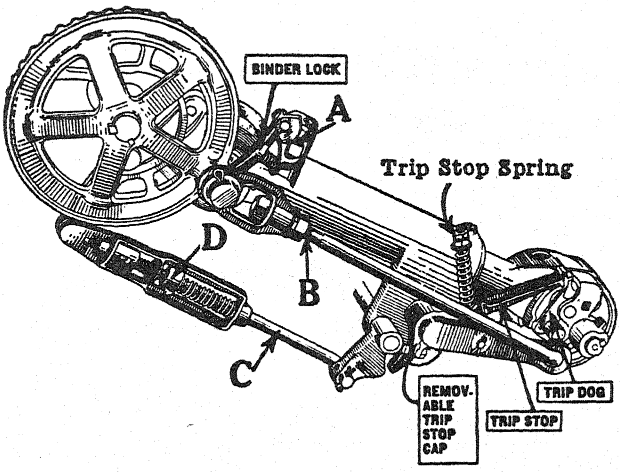


FIG. 199. Trip stop, compressor spring, and needle pitman.

latched, whereupon the needle shaft and knotter shaft come into action. (When the trip stop is latched, both shafts are idle.) The needle moves forward and upward, through a slot in the deck. The needle point carries the twine over the knotter hook and into the twine-holding disk, thus wrapping it around the bundle of grain. At this point in the revolution of the knotter shaft, the gear teeth on the knotter cam come into mesh with the two pinions (Fig. 198*d* and *f*). The knotter hook and twine disk revolve, the knot is tied, the ends are cut, and the bundle is formed.

Larger bundles may be made by setting the trip hook farther back. Several holes are provided for this purpose. Tighter bundles may be obtained by increasing the tension of the compressor spring, shown in Fig. 199*D*. The bundles may be made tighter also by increasing the tension of the trip-stop spring in the type of binder here illustrated.

Adjustments similar to those described and illustrated above are provided on all types of binders.

Bundle Carrier (Fig. 200). The bundle carrier is attached to the main frame of the binder. The bundles are thrown by

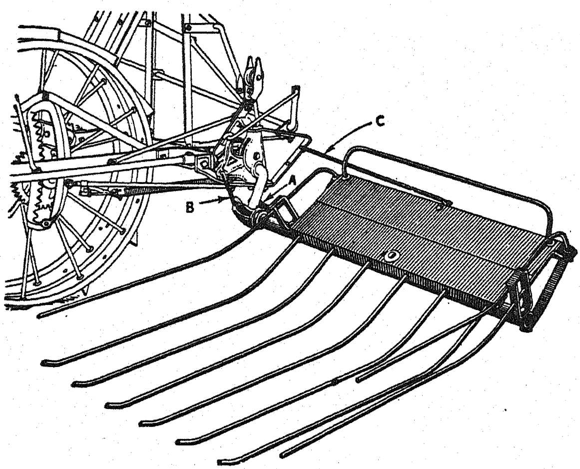


FIG. 200. Bundle carrier.

the discharge arms from the deck of the binder to the bundle carrier. When several bundles have accumulated on the bundle carrier, the operator dumps it by means of a foot lever located near the driver's seat. After the bundles have been dumped off, a coil spring returns the bundle carrier to its original position.

This action of the bundle carrier makes it possible to drop

the bundles in rows across the field. This saves much time in later harvesting operations.

Tongue Truck. Horse-drawn binders are usually equipped with a tongue truck. This requires the use of both a stub pole and a long pole. A tongue truck is very desirable. It supports the forward end of the binder and relieves the horses' necks of all weight. The stub tongue is connected to the main frame and braced to a point near the inside divider.

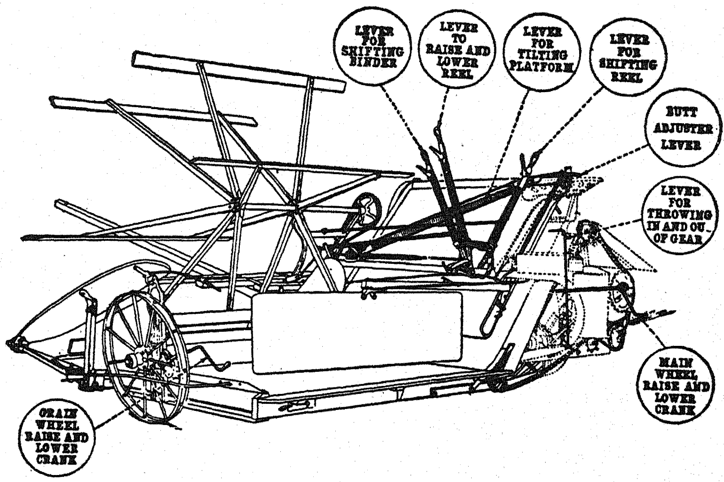


Fig. 201. Levers used on a standard type of grain binder.

Tilting Lever (Fig. 201). The long tilting lever is connected to the stub pole by means of steel braces. The setting of this lever controls the tilt of the cutter bar. The guards may be tilted down for picking up lodged or tangled grain.

JOB 15

TO THREAD THE NEEDLE AND TEST THE KNOTTER

Note. The following directions apply particularly to the McCormick binder, but may be followed in general for any other make.

Procedure

1. Pull the twine end out the center of the ball. Pass it through the holes in the top of the twine can (Fig. 202*b*) and close the cover.

2. Pass the twine through the holes in the braces (*c* and *d*).

3. Spring open the roller tension (*e*) and pull the twine

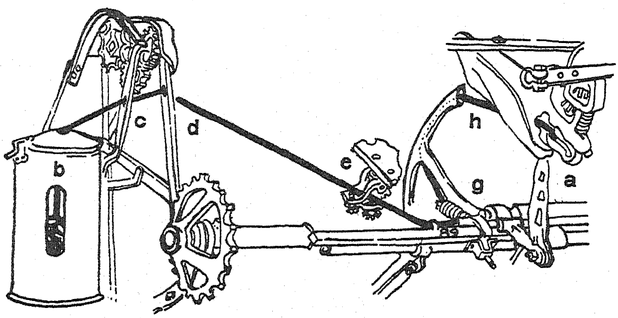


FIG. 202. Threading the needle.

through it. This tension may be adjusted by means of a regulating nut. It should be so tight that no slack is permitted in the twine between the tension and the twine-holding disk.

4. Pass the twine through the eyelet (*g*) and also through the eyelet on the back of the needle.

5. Thread the twine through the needle and out at *h*. Pull several feet through the eye of the needle.

6. Hold the free end of the twine tight with one hand. Pull back the trip hook (Fig. 203) and revolve the discharge arms.

7. Continue the revolution of the discharge arms (*B*). This causes the needle to pass the twine into the twine-holding disk, where it is retained. Pull the knot off the knotter hook.

8. Test the knotter by tying several knots. To do this, the following steps are necessary:

(*a*) Pull a little twine (about 1 foot) through the needle and hold it taut with one hand.

(*b*) Pull back the trip hook.

(*c*) Make one complete revolution of the discharge arms.
(*d*) Pull the knot off the knotter hook.

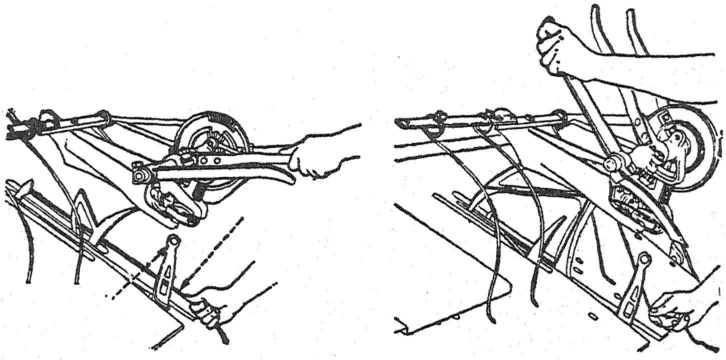


Fig. 203. Entering twine into twine-holding disk.

Special Equipment

Header Attachment. This is used in place of the regular binding attachment when the grain is too short to cut; or else, for other reasons, it is desired to cut the grain just below the heads. The cut heads are delivered to a truck by a canvas elevator.

Flax Attachment. This method of handling flax is used instead of an attempt to bind it with the regular binding attachment. The cut flax is accumulated in the curved rods until the rod assembly is raised by the operation with the regular bundle carrier foot lever, and dumped.

Lodged Grain Guard. The long flexible point is fitted over the regular guard to lift tangled grain and direct it to the cutter bar.

Extension Dividers. Long and tangled grain is divided more easily and directed to the knife by means of this extension.

Transport Trucks. It is both convenient and economical to have a binder equipped with transport trucks. When these are used, the stub pole and tongue truck are connected underneath the outer end of the platform. The axles of the transport

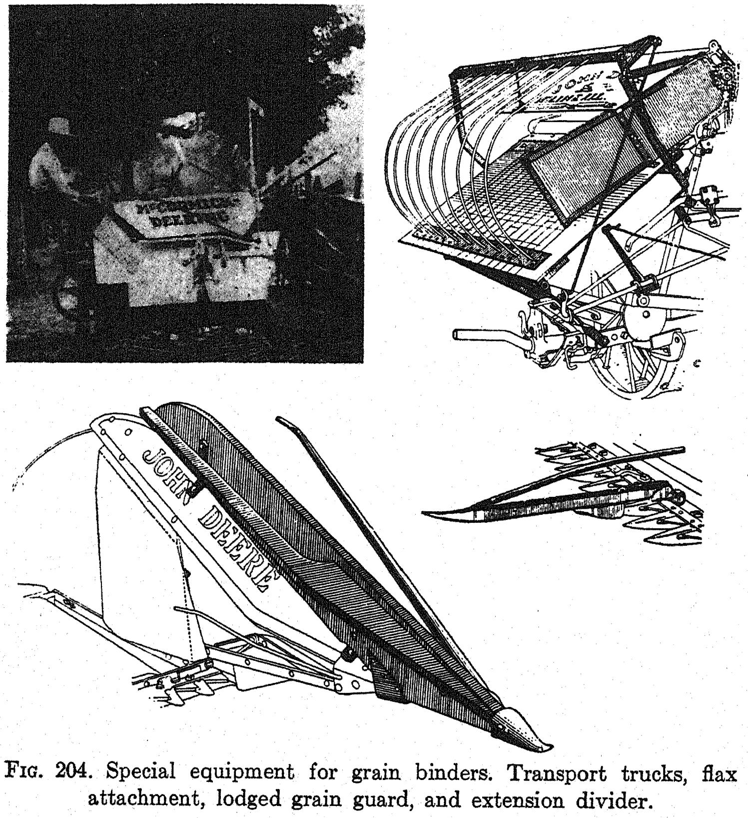


FIG. 204. Special equipment for grain binders. Transport trucks, flax attachment, lodged grain guard, and extension divider.

trucks are carried in castings bolted to the main frame. The binder is drawn from the outer end of the platform. This permits travel on narrow roads or through woods, etc., as the machine requires less space when drawn in this manner.

Transportation on hard-surfaced roads is also made easier by transport trucks.

Reel Slip Clutch. This is a desirable accessory in extra-heavy or weedy crops.

Engine Drive. A special engine may be attached to drive the binder mechanism instead of taking power from the main wheel. In situations where the ground wheel cannot get sufficient traction, owing to wet ground, unusually heavy straw, a mixture of heavy weeds and grass and similar conditions, mounting a separate engine makes possible the saving of a crop which might otherwise be lost.

JOB 16

TO REPAIR A GRAIN BINDER

Procedure

1. Get owner's or operator's report on the condition of the machine, broken or worn parts, faulty adjustments, field troubles, etc. Secure the appropriate repair catalog and instruction book.
2. Test and inspect all parts. Remove gear cases, covers and shields and clean the parts to facilitate careful inspection. It is suggested that the inspection be divided into sections as indicated below.
3. Make a list of all repair operations needed.
4. Order the repair parts required.

Main Wheel and Countershaft

1. Test the main wheel to see that it is square with the frame. The raising pinions on each side of the main wheel should be entered equally into the side brackets of the frame. Each raising pinion has one marked tooth. This is to aid in getting the pinions properly entered into the teeth of the side brackets.
2. Jack up the main frame and test the bearings on the main-wheel axle. (These are large roller bearings and seldom wear out.) Lubricate them well through the oil holes.

3. Examine the main-wheel sprocket and the main chain for wear (see Figs. 241 and 242).

(a) Is the main chain assembled in the proper manner?

4. Test the main-wheel raising device and see that it works freely. Frequently the cotter pins used to attach the raising worm to the raising crank are not properly spread and prevent the worm from turning. Lubricate these parts well with a hand oil can.

5. Check the alignment of the clutch sprocket and the main-wheel sprocket. Difficulty in keeping the main chain on is sometimes experienced because these sprockets are out of line. Replace the clutch sprocket if it is badly worn.

6. Engage the clutch and test the tension of the clutch spring. Both the clutch and clutch sprocket should be replaced if the notches are worn.

7. Test the bearings of the countershaft. These are roller bearings and are easily replaced if necessary.

8. Adjust the countershaft to take up the wear between the bevel gear and the bevel pinion. To accomplish this, it is necessary to force the countershaft outward with the adjustment shown in Fig. 185. If possible, force the bevel pinion forward also, by putting a washer between the crank-shaft bearing and the bevel pinion. This will give a better mesh between the gear and pinion.

9. Clean out the oil holes of the countershaft bearings and main-wheel bearings. Lubricate these bearings thoroughly. Clean the housing enclosing the bevel gears and refill with fresh oil.

Elevators, Rollers, Canvases

1. Remove all canvases. Examine the leather straps and replace any that are worn or broken. Inspect the canvas slats and see that the canvas is securely tacked to each slat.

2. Turn each roller in its bearings. See that all the rollers

turn easily. Replace any worn bearings. Clean out all oil holes that lead to the bearings of the rollers and lubricate them well.

3. Square up the elevators. This may be done by testing with a carpenter's square or by measuring with a stick between diagonally opposite corners. The distance between each pair of diagonally opposite corners should be equal.

The elevator brace rods may be shortened or lengthened to make these measurements equal.

4. Examine the elevator chain or apron chain. See that it is put on properly. Replace any sprockets that are worn. Check the alignment of all the sprockets over which the apron chain runs. Clean out all the oil holes in the sprocket bearings and lubricate them thoroughly.

Cutter Bar, Sickle, Pitman

For this problem the same procedure may be followed as for mowers. The repair work to be done on these parts is so like that necessary on mowers that the same outline will be satisfactory, with the following exceptions:

(*a*) Binders have no means of aligning the cutter bar.
(*b*) No provision is made for registering the sickle.
(*c*) Binder-sickle sections are serrated; they are not resharpened, but must be replaced when worn. (For special grass crops, smooth sections may be secured.)

Reel

1. Examine the sprockets, gears, and chains that drive the reel. See that all are in proper alignment. Replace any worn parts. Be sure that the reel-driving chains are put on properly.

2. Test the bearings of the reel shaft in the reel frame. These bearings are removable.

3. Level the reel shaft. The outside end of the reel on used binders tends to sag down. Where outside reel supports are used, the outer end may be raised into position by shortening the chain attached to the outside bar. Binders with no outside

reel support usually have an adjustment on the reel frame to maintain the outer end of the reel shaft at the correct height.

4. Disconnect the reel-driving chain. Revolve the reel and make sure that none of the reel slats strike the inside or the outside divider. The inner ends of the reel slats should come to a position over the cutter bar, slightly before the outer ends.

5. Replace cracked or broken slats or arms.

6. Paint all wooden parts of the reel and the reel shaft.

7. Loosen, clean, and readjust the reel slip clutch (if present).

Binding Attachment

1. Tie several knots with the binder attachment to determine if all parts are working properly. To do this, refer to the directions on p. 272.

Failure to tie properly may be caused by several things. The most common troubles are as follows:

(*a*) Knotter spring (Fig. 198*e*) too tight.
(*b*) Knotter spring too loose.
(*c*) Twine-holding disk too tight. Adjust by the setscrew (Fig. 198*g*).
(*d*) Twine-holding disk too loose. Adjust with setscrew (Fig. 198*g*).
(*e*) Needle bent or out of adjustment so that it does not place the twine in the disk properly.
(*f*) Twine tension (*e*) too loose.
(*g*) Twine tension too tight.

The following instructions are reprinted from the instruction book of the International Harvester Co., and refer to the McCormick-Deering grain binder:

1. Keep roller tension tight (not too tight).

2. Do not try to regulate size or tightness of bundles with the tension on the twine or by adjusting the knotter spring.

3. If the bundle is thrown out not tied, find the reason in the following three causes:

(*a*) Twine-holding disk may be too loose, which allows the twine to slip out while the knotter hook is making revolutions.

(*b*) Twine-holding disk may be so tight the twine cannot slip through the disk. This will break the twine.

(*c*) Needle may not come down far enough to place upper twine in the disk safely.

If bundle is thrown out not tied, with twine straight and no knot in it, the knotter spring is too loose, and may be adjusted.

Do this carefully, as the average operator will usually give the set screw a full turn each time he attempts an adjustment, and this is frequently the cause of failure to correct the trouble. Give the set screws a quarter of a turn each time a change is made. If the trouble is not overcome by adjusting in one direction, be sure and change the screw back to its original position. Then try adjusting in the opposite direction.

Don't make the spring too tight on the knotter or it will break the twine.

Needle is set at exactly the right point before the binder leaves the factory and must not be changed. Binder works best when just enough tension is kept on twine to prevent it from getting slack.

2. Examine all working parts of the binder attachment and replace badly worn cams or gears.

NOTE. Whenever two gears mesh together on the binding attachment, timing marks are provided on the teeth, for convenience when reassembling these gears. If such marks cannot be found, make punch marks on the gears before taking them apart. They must be assembled in the proper relation.

3. Lengthen the needle pitman if necessary (Fig. 199*B*). In old binders it is often necessary to make the stroke of the needle longer in order that the needle may carry the twine to the twine-holding disk properly.

4. Tighten the bearings of the packers. These are usually made in halves. One-half may be removed and filed down. This will allow the bearing to be drawn closer together.

5. Remove the twine knife and sharpen it with an oilstone. If it is badly worn, replace it with a new one.

Remove and clean the twine tension (Fig. 202*e*). Frequently matter becomes wedged into the moving parts of this tension, so as to prevent its proper operation.

Miscellaneous

1. Test all the levers to see that they operate freely. Examine the lever detents and replace any that are worn.
2. Operate the bundle-carrier trip lever. Adjust the tension of the bundle-carrier return spring so that the carrier returns to its normal position quickly.
3. Oil all the chains used on the binder by first dipping them in kerosene and then either dipping in oil or brushing with an old paint brush dipped in oil.
4. Paint the sheet-iron bottom of the platform to prevent rusting.
5. Oil all the bearings and moving parts of the entire machine before storing it away.
6. Remove tongue-truck wheels and examine the axles. Grease or oil these.
7. Remove the grain wheel and wash the roller bearing clean. Clean out the oil tube in the grain wheel which leads to this bearing. Replace roller bearing and grain wheel. Lubricate thoroughly.
8. Loosen and clean the slip clutch used on the power drive shaft (if power-driven binder), then readjust to proper tension. Clean and oil chains from power shafts; readjust their tension.

Operating a Grain Binder

Lubrication. Almost all of the recent binders are supplied with fittings for applying grease with a compressor. Bevel gears —between countershaft and crank shaft—are usually enclosed in an oiltight reservoir. Elevator and butter driving gears are enclosed in some models. The conditions under which binders operate—dust, grit, chaff, straw, etc.—make frequent and thor-

ough lubrication a necessity. Oil holes and grease fittings become plugged and obstructed and must be cleaned before they will admit lubricant.

A list of the principal parts requiring lubrication includes main wheel and grain wheel; raising device on each wheel; elevator rollers; shafts of the binding-attachment packer cranks; bearings of the countershaft and crank shaft; pitman; crank and sickle head; sickle; chain-adjusting idlers; reel-shaft and reel-driving parts; adjuster shafts and pivots; lever latches and detents; tongue truck wheels.

Preliminary Operation. Place the large end of the raising crank on the square end of the crank-shaft sprocket and turn the mechanism manually to be sure all parts work freely. If they do not, remedy the trouble before driving the parts with power. Adjust the power drive shaft on tractor binders so that it forms as straight a line as possible between the tractor and binder.

Before entering the grain it is well to put the binder in gear and run it idle for a few minutes. This gives the operator a chance to see that all parts are working properly. This practice is especially desirable with a new machine.

Caution. Always throw the binder out of gear when working on it while the horses or tractor are attached to it. A good grade of lubricant should be used. The binder has many rapidly moving parts that will heat and wear out quickly if inferior lubricants are used.

Threading the Needle. Tie the outside of one ball of twine to the inside of another and put both balls in the twine can. The twine should feed out from the inside of the top ball. Thread the needle as instructed on p. 272.

Field Plan. Binders are driven around the field, not back and forth across the field like the plow or cultivator. The work is started at one corner of the field, and the binder is driven clear around. Each succeeding swath is nearer the center of the field.

Some difficulty is experienced by beginners at the corners of the field. The swath cut must be kept full width at the corners. Otherwise a long, pointed strip (an acute angle) of uncut grain will be left at the corners. This makes turning very difficult, and so a loop turn such as that shown in Fig. 179 is used by many operators; the sickle should always be moving before the binder enters the grain.

If the field is fenced, the horses or tractor must be driven through the standing grain when the first swath around the field is cut. The grain that is thus left standing may be cut by running the binder around the field in the opposite direction. Unless the grain is overripe, little will be lost while cutting the first swath by the horses or tractor passing over it.

Height of Cut. The position of the raising cranks (on main wheel and grain wheel) determines the height of the platform above the ground. This distance may be regulated by the raising cranks so that the straw may be cut at any length desired.

For cutting short grain it is not advisable to lower the platform too much. It is better to tilt the guards downward.

The tilting lever (Fig. 201*e*) should be set so that the cutter bar is nearly level. A slight tilt downward is desirable, where there are no obstructions in the field.

When the grain is badly lodged or tangled, the guards may be tilted down until they are close to the ground. This is also advisable for cutting short grain.

Adjusting the Reel. The reel fans should strike the grain just below the heads. The reel should be set far enough back so that the cut grain is placed well on the platform but, if too far back, the grain will be thrown over the rear of the platform.

The reel fans should not leave the grain until after it is cut. Their function is to hold the grain against the sickle until it is cut.

Bundle Carrier. Drop the bundles at equal intervals by operating the foot dumping lever or trip rope.

The distance between "dumps," or windrows, will vary according to the grain. In heavy grain the bundles must be dumped more frequently than in light grain, consequently the windrows are nearer together in heavy grain. Bundle carriers are large enough to carry six or seven bundles easily. The first time around the field, the bundle carrier is dumped each time it is full. It should be dumped at the same place during each succeeding round.

Forming the Bundle. The adjuster lever must be set to shape the butts of the bundles properly. Under ordinary conditions the adjuster should be set as far toward the front of the binder as possible. In short grain it is necessary to pull the adjuster toward the rear of the binder. This is done with the long rod, or adjuster lever, near the driver's seat. Moving the adjuster rearward causes it to push the cut grain also toward the back of the binder deck. This will result in the bundle's being tied near the middle, which is always desirable.

The binder-shifting lever moves the binding attachment backwards or forward. It should be set so that the band is in the center of the bundle.

The size of the bundles is regulated by the trip hook. Moving the trip hook in makes the bundles smaller. Several bolt holes are provided at this point so that a considerable range of adjustment is possible. Small bundles are desirable for heavy, green, or tangled straw. Large bundles may be made if the straw is straight and dry.

The tightness of the bundle is regulated by the compression spring (Fig. 199*D*). Increasing the tension gives a tighter bundle. Tight bundles are desirable for clean, dry straw, and loose bundles for tangled, green, or heavy straw.

Aprons and Windboards. The aprons should be kept just tight enough to prevent their slipping when loaded with grain. If they are too tight, unnecessary friction and wear are caused.

The windboard at the rear of the binder deck may be folded

and locked into a horizontal position. This leaves more open space on the deck, which is desirable when cutting long straw.

The wooden platform deck is hinged to the rear of the platform. For short grain it should be raised to a vertical position. For long grain it should be in the horizontal position, forming an extension to the platform.

The cloth curtain, or wind break, at the rear of the platform may be swung forward or backwards as required in order to protect the grain on the platform from wind and to prevent its being carried over the rear of the platform.

Field Troubles

Grain binders give very little trouble when properly adjusted. They accomplish in a dependable manner a difficult and complex operation. It is not practical to operate the binder when the straw is very wet, while the dew is heavy, or during a rain. Under such conditions much trouble is experienced with slipping canvases and with the straw's winding up on the rollers.

Overripe grain also presents a difficult condition, as the action of the packers and of the discharge arms threshes out much of the grain, which is lost. The cutting must be done at the proper time for best results. Dry straw cuts easily and is handled without trouble by the various parts of the binder.

Some of the troubles that may occur in the field are given below with the cause and the remedy for each.

1. Bundles Missed (Not Tied)

Note. Do not stop the binder because an occasional bundle is missed. If any real trouble exists, bundles will be missed frequently.

(*a*) Twine disk too loose (or too tight).

Remedy. Adjust to proper tension.

(*b*) Twine tension too loose, or too tight, or tension rollers stuck.

Remedy. Adjust to proper tension; oil tension rollers.

(*c*) Knotter hook too tight or too loose.

Remedy. Adjust to proper tension.

NOTE. Directions for making these adjustments were given on p. 278.

(*d*) Twine knife too dull.

Remedy. Remove and sharpen the knife or replace it with a new one.

(*e*) Needle bent or out of adjustment.

Remedy. Straighten and adjust so that it places the twine in the twine-holding disk properly. The forward stroke of the needle must be sufficient to carry the twine into the disk. Keep the point of the needle sharp. The point should project slightly above the deck, when it is not in motion.

2. Bundles Too Loose or Too Tight

Remedy. Loosen the compressor spring to make looser bundles. Tighten it to make the bundles tighter.

3. Bundles Too Large or Too Small

Remedy. Move trip hook in for small bundles, out for large bundles.

4. Discharge Arms Continue To Revolve

(They should revolve only when it is necessary to discharge the bundle.) This is caused by the failure of the trip stop to engage properly with the driving dog opposite it. This failure may be due to some part's sticking, owing to lack of lubrication. It is usually caused by a worn trip stop or by a worn driving dog or a weak compressor spring (Fig. 199).

Remedy. Replace worn parts.

5. Chains Come Off Frequently

The straw may be too wet. In this case it will wind around sprockets and rollers and force the chain off. Worn chain links

sprockets that are out of line, or chains that are too loose may account for the trouble.

Remedy. Align sprockets and assemble chain properly, replacing it with new chain if necessary.

6. Canvases Slip or Stop

The causes of this trouble are loose canvases or sticking rollers.

Remedy. Tighten the canvases, lubricate and loosen the bearings of the rollers. Determine if the rollers are square with the elevators.

7. Bundles Drag on Bundle Carrier

This often occurs because the foot lever and the rod which operates the bundle carrier are bent out of adjustment. The action of the foot lever should swing the bundle-carrier fingers back (or down) far enough to make the bundles slide off.

Remedy. Adjust the rods between the bundle carrier and the foot lever to give more backwards (or downward) movement to the fingers of the carrier.

8. Bundle Carrier Does Not Return Properly

The cause is a weak return spring, which must be tightened or, if necessary, replaced with a new one.

9. Main Wheel Slips

All binder parts stop. This may be caused by wet or slippery ground. Under such conditions the main wheel has no grip or traction.

Tight bearings, heavy grain, bent shafts, or a compressor spring that is too tight may also cause the trouble. Broken chain links, chains too tight, or chains climbing the teeth of the sprockets may cause the main wheel to slip.

Remedy. See that all chains and sprockets are properly adjusted. Test all moving parts to locate the cause of excessive draft.

CHAPTER VIII

FERTILIZER-DISTRIBUTING IMPLEMENTS

The application of fertilizer is now required in practically all parts of the United States. The number of machines used for the purpose has increased rapidly during the past decade. Modern machinery meets this problem well: distribution is rapid and uniform; the amount per acre may be accurately controlled; and the fertilizer is pulverized well while being distributed, thus being made quickly available. Machines are employed for spreading lime and distributing commercial fertilizer. The manure spreader, especially, is a standard part of the farm equipment. On many farms it is used more frequently than any other implement.

Commercial-fertilizer Distributors

Commercial fertilizers are applied to the seed bed in several different ways: they are broadcast over the field before planting; applied in bands on each side of the row at the time of planting, in prepared rows before planting, and at various stages during the growth of the crop. Seeding, planting, and cultivating implements are equipped with attachments for distributing fertilizer as has already been noted. But, as the use of commercial fertilizer and lime for an almost endless variety of crops presents so many problems and requirements, special machines are available for the work.

Wheel-barrow Distributors. In this hand-propelled type the fertilizer is distributed through six adjustable spouts, which may be set to broadcast a band from 4 inches to 30 inches wide. The spouts may also be set to distribute in the middles of 14-inch rows, or to side-dress each side of two rows. The hopper capacity is 50 pounds.

The rate application is controlled by an adjustable outlet; the quantity may be varied from 200 to 2000 pounds per acre. An agitator in the hopper bottom, is operated from the drive

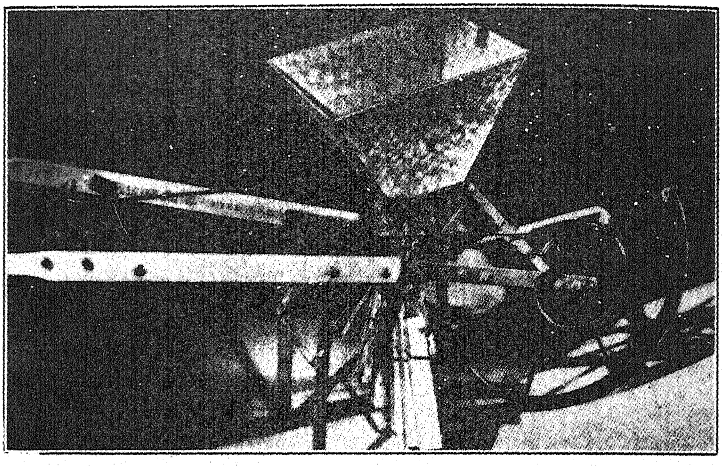


FIG. 205. Hand-operated fertilizer distributor.

wheel and serves to maintain a free flow of material and prevent its bridging across the outlet.

One-horse, One Row. This type is used for preparing rows in which the crop is to be planted. It may be equipped with a plow furrow opener, placed ahead of the fertilizer delivery and with a stirring or covering disk behind. These combinations mix the fertilizer with the soil more thoroughly. The disks also throw up a ridge or bed for planting.

One-horse, Three Row. Designed especially for preparing rows to be planted or for side-dressing rows of growing crops, this type employs three feed belts to carry the fertilizer through adjustable outlets to the three sets of tubes. The hopper is low and the ends of the tubes only 5½ inches from the ground, a desirable construction feature which makes the hoppers easy of access and lessens the blowing due to wind.

High Wheel with Tractor Hitch. Designed primarily for broadcasting before planting or for top-dressing crops, meadows, orchards, etc., this type is furnished with a 7-foot hopper

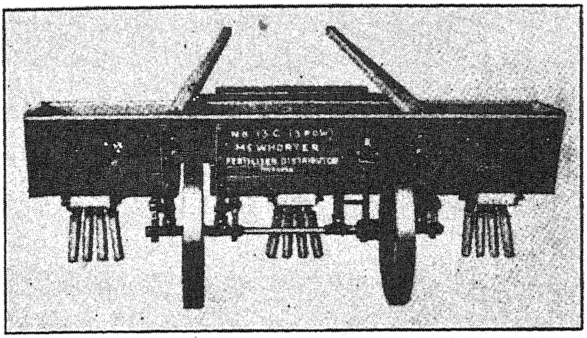


FIG. 206. One-horse, three-row fertilizer distributor.

holding 6½ bushels or with a 9-foot hopper holding 8½ bushels. The machine is light (500 to 600 pounds) and may be

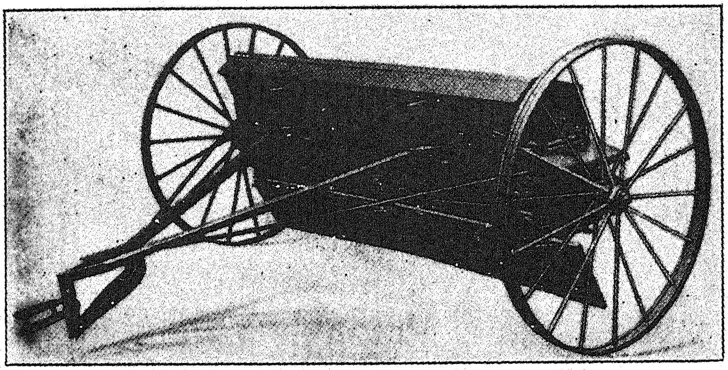


FIG. 207. High-wheel fertilizer distributor with tractor hitch.

operated with a single horse or light tractor. The quantity distributed per acre may be varied 10 to 2350 pounds.

Pulverizing or agitating is necessary to cause fertilizer to flow evenly and uniformly. In the type illustrated, the feeding

Liquid-fertilizer Distributors. The custom of distributing liquid fertilizers, or fertilizers in solution, is becoming more common. Good results are claimed, owing to the ready

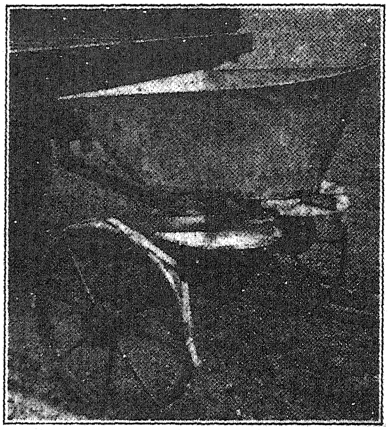


FIG. 210. Trailer-type lime spreader or fertilizer distributor.

availability of the fertilizer ingredients. Machines for this purpose are now available.

Maintenance

Most fertilizer ingredients except the organic constituents are soluble in water when received on the farm. But many of these soluble inorganic chemicals change to insoluble compounds when exposed to air and moisture, and become set and hard. Consequently it is highly desirable to clean distributing implements carefully immediately after each use. If lime or commercial fertilizer is left in the hopper and feed mechanism, it becomes exceedingly difficult to remove.

Most farm fertilizers contain sulphate of ammonia which is quite acid and has a distinct corrosive or pitting effect on metals. Superphosphate, another fertilizer constituent, may also cause corrosive action. Although the hoppers and bottoms of some designs are especially treated with lead or copper

to lessen corrosion, it is well to protect the metal surfaces of the feeding device by thorough cleaning and painting before the machine is stored.

Manure Spreader

The manure spreader is widely used. The quality of the work accomplished by this machine is far superior to hand work and much more economical.

Fig. 211. Horse-drawn spreader.

The manure spreader should pulverize thoroughly and spread a uniform layer of the desired thickness. Bunching and lumps must be eliminated, and the desired rate of distribution must be maintained whether the machine is moving uphill or downhill.

Adjustments are necessary to provide for a light top dressing as well as for a heavy application to be plowed under. Most manure spreaders can be adjusted to distribute about 6 to 24 loads per acre.

Sizes. The size is expressed in bushels. The size most widely used holds about 60 bushels of manure. Such a machine is considered a load for two horses. Machines with a capacity of 70 to 75 bushels are also manufactured, and usually require three horses. Either size is easily operated by a small farm tractor. They may be equipped with a stub pole for tractor operation.

Special tractor models are trailed types with levers and controls mounted within reach of the tractor seat to permit one main operation. The front wheels are eliminated and the spreader is coupled directly to the drawbar of the tractor with an adjustable front hitch, including an adjustable stand for support when loading. Pneumatic tires are preferred for use with this implement. Although steel wheels can be secured, and they do lessen the original cost, it is likely that pneumatic tires will greatly increase the years of service.

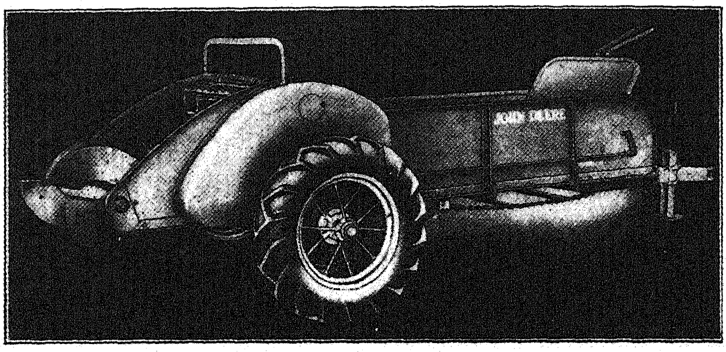


FIG. 212. Tractor-drawn manure spreader.

Power is taken from the rear wheels for driving the mechanism of the spreader; power take-off drive from the tractor has not proven desirable.

Construction and Principal Parts

Frame. The frame extends through the entire length of the machine. It is subjected to heavy strains and must be strongly built and well braced. The outer sills are made of steel. The cross sills may be of wood or steel. Diagonal braces are used to maintain the alignment of the main sills. Misalignment, sagging, or twisting would cause binding of the working parts, heavy draft, and frequent breakage of the driving mechanisms.

The frame is the central part of the machine, and on it many other parts depend:

1. The front truck (Fig. 213*b*) is connected to the front end of the frame.

2. The rear axle and wheels (*a*) are attached to the rear end of the frame.

3. The frame supports the box, which holds the load, and the conveyor or apron, which moves the load.

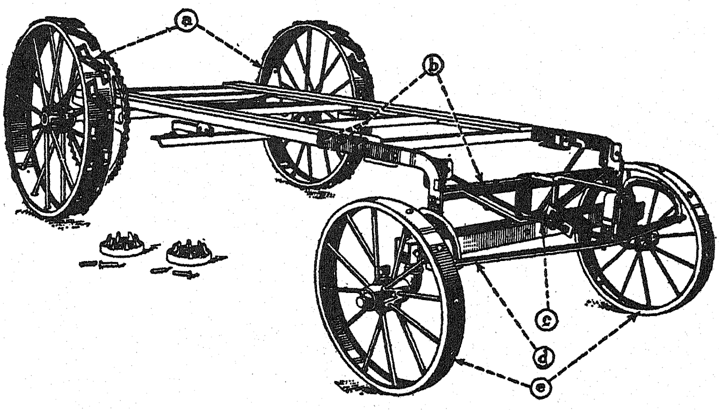


FIG. 213. Manure spreader frame and wheels.

Conveyor or Apron. The conveyor, or apron, carries the load slowly backwards and delivers it gradually to the revolving beaters. An apron of the simple conveyor type has recently become the standard. This type is shown in Fig. 214. It is made up of angle-steel slats which are connected at the outer ends to steel chain links. This apron, or chain of slats, is driven by a shaft near the rear of the spreader. Grease cups or some other means of lubrication are always provided on this drive shaft. A sprocket is carried on either end of this shaft, to engage with and drive the apron chain. The front apron shaft is not a driving shaft.

One method of regulating the tension of the conveyor is by means of the adjusting screws at each side of the front apron shaft (Fig. 218).

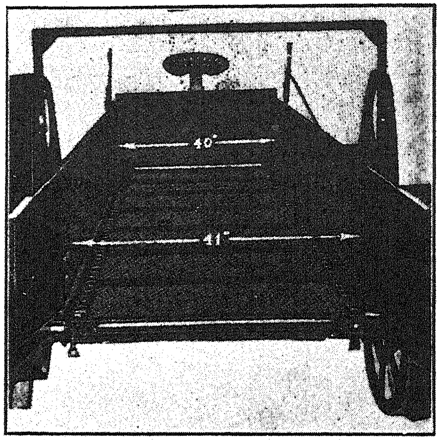


FIG. 214. Interior view of spreader box showing conveyor or apron.

Conveyor or Apron Drive. Figure 215 shows one type of apron drive. The large ratchet wheel (10) is keyed to the

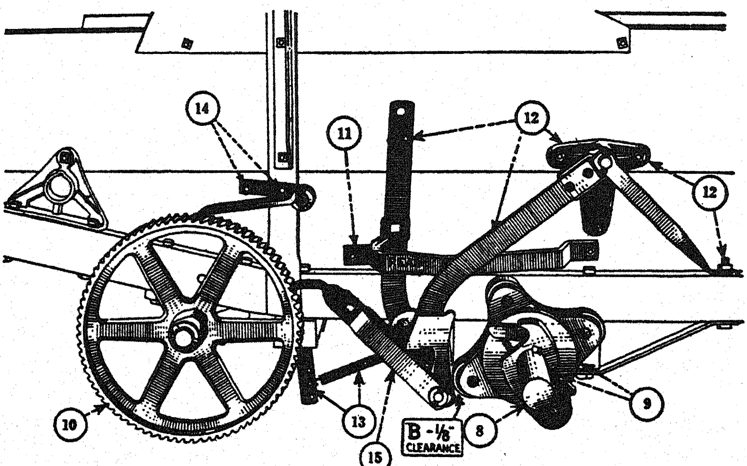


FIG. 215. Apron drive. 8—Main axle. 9—Four-point drive cam. 10—Ratchet-wheel conveyor drive. 11—Guide bracket for cam arm. 12—Rocker-arm assembly. 13—Spring and anchor. 14—Ratchet-wheel stop 15—Ratchet-wheel drive pawl.

outer end of the conveyor drive shaft. A rocker-arm assembly (11 and 12) is mounted in front of the conveyor shaft. A pawl is secured to the rocker arm. The rocker arm is depressed by the large, four-point cam on the rear axle.

The motion of this rocker arm causes the feed pawl to engage with the teeth on the ratchet wheel (15) and drive it. An adjustable cam arm (12) regulates the number of teeth engaged by the feed pawl (15). In this way the speed of the conveyor shaft is regulated. The setting of this feed stop, therefore, determines the rate of distribution or the number of loads per acre. The position of the feed stop may be regulated from the seat by means of a hand lever.

Rear Axle (Fig. 216). The rear axle supports most of the weight of the machine. It is a driving axle, or "live axle," and furnishes the driving power for all the working parts. The

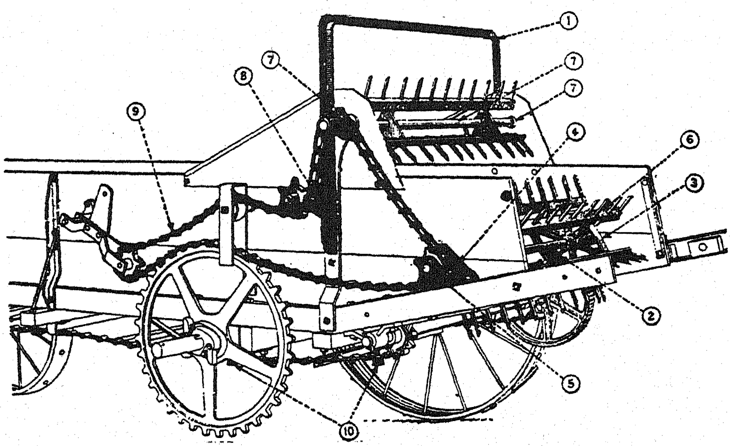


FIG. 216. Beaters and beater drive chain.

placement of the rear axle varies on different types of spreaders. In some it is placed above the main frame, and in others below. Thus the weight of the frame and the load is either carried

above or suspended from the rear axle. The rear wheels drive the main axle by means of pawls and ratchets. The construction and action of pawls and ratchets are discussed on p. 118. Power for driving the beater is secured from a large sprocket which is keyed to the main axle.

Beaters (Fig. 216). Spreaders are now commonly equipped with two beaters. The horizontal bars of the beater are made of steel. The teeth are usually riveted into the bars.

Both beaters have the same direction of rotation. The upper or smaller one pulverizes and discharges the upper part of the load. The lower and larger beater handles the main part of the load. The upper beater makes about nine revolutions to one of the main wheels. The lower beater turns approximately at the rate of 6 to 1.

Beaters should be well supported at both ends by large, easily lubricated bearings. The pressure of the load against the beaters and the work of pulverizing is heavy. Strong construction, adequate bracing, and good bearings are essential in beater design. Some machines are now being equipped with roller bearings. This is an excellent practice.

Beater Drive (Fig. 216). The beaters are usually chain driven. The power is taken from a large drive sprocket keyed fast to the rear axle. This sprocket also carries the main-drive pawls. When the spreader is in action a large chain (9) is lowered onto the drive sprocket. This chain is raised from the sprocket when the load has been distributed. Sprockets are mounted on each beater shaft (7 and 5). The drive chain passes over these sprockets and under an idle sprocket or chain tightener. An angle cross tie (1) is used to maintain proper alignment and spacing of the beater shafts.

Box (Fig. 217). The spreader box is made up of the following parts: bottom, sides, front endgate, and reargate (supplied as extra equipment).

The bottom of the box is tight. It is constructed of wood

or sheet metal. Matched flooring material such as yellow pine is frequently used. This construction prevents loss in distribut-

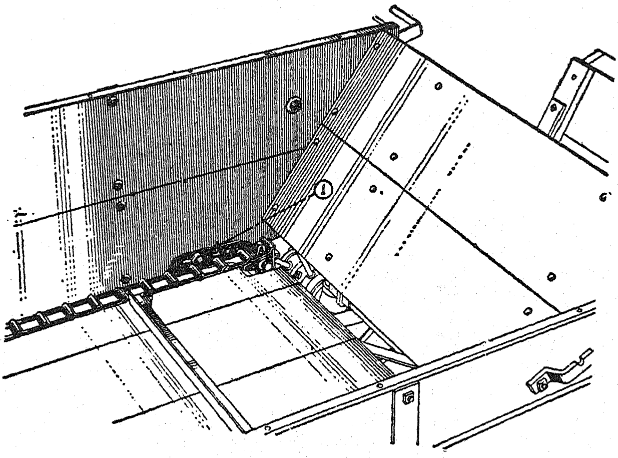


FIG. 217. Front endgate and conveyor tightener.

ing liquid manure. It also prevents material from falling through and collecting on the underside of the apron, as frequently happened in the open-bottom type of spreader.

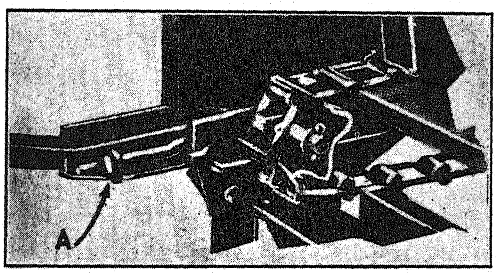


FIG. 218. Conveyor or apron tightener.

The front endgate slants forward, making it possible to heap up the load in front. When the load is carried backwards by the conveyor, the top of the heap will fall forward against

the slanting endgate and thus be leveled out. The location of one of the front conveyor sprockets and apron tightener is shown in Fig. 217. Another type of apron tightener is shown in Fig. 218*A*.

A rear endgate may be secured as special equipment. Figure 219 shows it raised or in position for unloading. The rear endgate is especially useful when distributing wet manure.

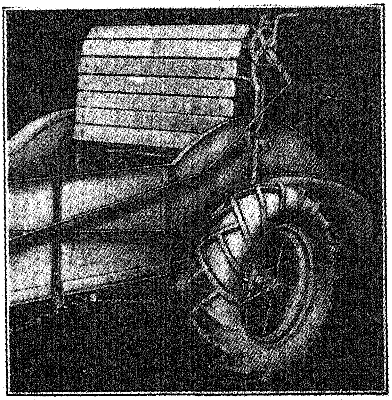


FIG. 219. Rear endgate.

It also prevents loss on the way to the field and packing against the beaters.

An inside view of the box is shown in Fig. 214. The box is narrower in the front than in the rear. This fact causes the load to loosen as it moves backwards, thus lessening the strain on the beaters.

Front Truck (Fig. 220). The conditions under which manure spreaders are used require a front truck of careful design and sturdy construction. Short turning is necessary, as the machine must often be loaded from barnyard corners that are difficult of access. Complete covering of the corners of fields also requires short, square turns. The machine is often used on frozen fields and on rough ground, as when driving

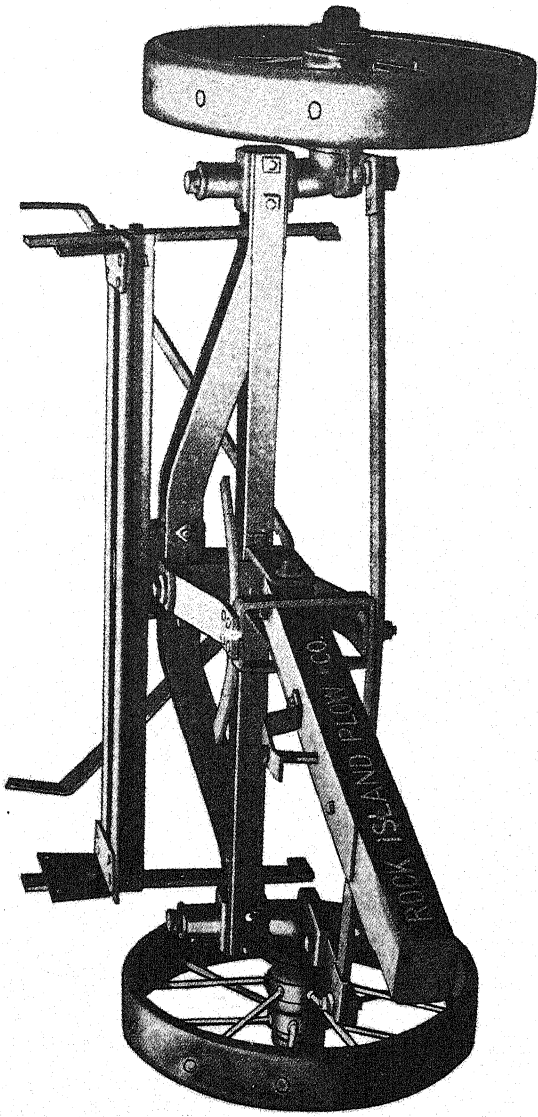


Fig. 220. Front truck.

across corn rows. The strain on the whole machine, and especially on the front truck, is severe.

The automobile type of front truck is used on practically all makes of spreaders. This construction requires a fixed front axle, with short pivotal axles or steering knuckles projecting from it. The wheels are mounted on the short pivotal axles. A truck of this type facilitates steering, makes short turning possible, and eliminates "whipping" or jerking of the pole on rough ground.

A fixed steel axle is combined with the front bolster. This extends across the entire width of the machine. The pivotal parts of this assembly correspond to the steering knuckles in an automobile. They are mounted vertically in suitable bearings at each end of the front bolster or fixed axle. The horizontal part of the pivotal axle carries the front wheels. Projecting from each pivotal axle is a short, flat bar or steering arm. Each steering arm is connected by an adjustable drag link to the bracket through which the pole passes. The rear of the pole is attached with a pivotal connection to the center of the front axle.

When the pole swings to one side in making a turn, the drag links move both wheels in the same direction. As the pivotal axle is close to the hub of the wheel, turning is easily accomplished.

The tires of steel front wheels vary 4½ to 5½ inches in width and 26 to 30 inches in height. The wheels are retained on the axles by collars which may be adjusted to take up wear.

Pneumatic tires for front wheels are usually 5.50 by 16 inches.

Rear Wheels. Steel rear wheels vary in height from 40 to 44 inches. The width of the tires is 4 to 6 inches. The tires are equipped with angle lugs to secure good traction. Pneumatic tires for rear wheels vary from 7.50 by 16 inches to 7.50 by 24 inches.

The rear wheels drive the rear axle by means of pawls

and ratchets. The pawl holder is keyed or pinned to the rear axle. The ratchet, with the teeth which engage the pawls, is fitted into the hub of the wheel. When the machine is moving forward, the rear wheels drive the main axle. When it is backed up, however, the ratchet or teeth in the hub of the wheels slip over the pawls and do not drive the axle. Roller bearings are used for the rear wheel.

Wide-spread Device. It is desirable to have the manure spread wider than the tread of the wheels. A spreader 6 feet wide should distribute the manure over a strip 7 to 8 feet in width. This makes it unnecessary to lap over the preceding

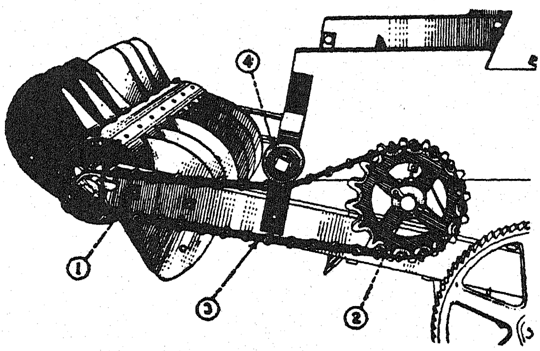


FIG. 221. One type of wide-spread device.

round with the spreader wheels, and lessens packing of the soil on wet fields.

The wide-spread device is in the nature of a third beater. Figure 221 shows one type of wide-spread mechanism. It is composed of a series of heavy steel blades, spirally arranged about a central shaft. The beaters throw the manure against the blades of the wide-spread mechanism. This revolves faster than the beaters, or about fifteen times as fast as the main wheels. One-half of the blades are inclined toward the left and throw toward the left; the other half are inclined toward

the right and throw toward the right. This widens out the spread without skimping the center. The wide-spread device is bolted to the rear of the frame as shown in Fig. 221. It is driven by the chain (3) from the sprocket (2) which is

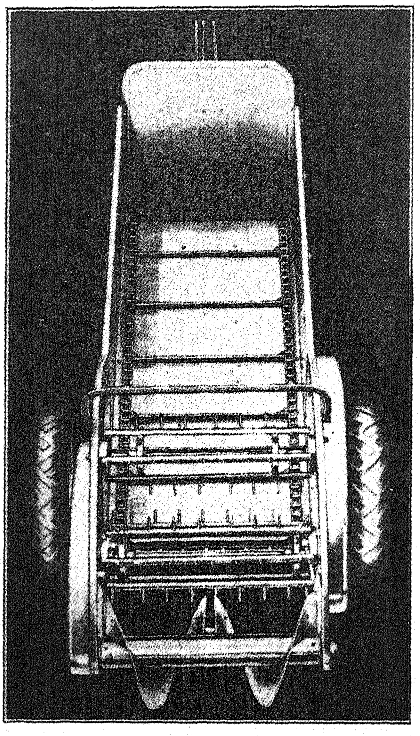


Fig. 222. Overhead view showing spiral wide-spread device.

mounted on the end of the beater shaft. An idler pulley (4) is provided for adjusting the tension of the chain.

Figure 222 illustrates a wide-spread distributor in the form of a spiral beater. One-half of the spiral is inclined to the right, and one-half to the left. In this way the width of spread is increased.

Levers. Two levers are usually provided on spreaders. One is the feed lever, which regulates the rate of distribution. The other is the throwout lever, which controls the beaters.

These levers are usually placed near the seat. The setting of the feed lever determines the number of teeth on the ratchet wheel to be engaged by the feed pawl. Moving the throwout lever raises or lowers the main drive chain.

Stub Pole or Tractor Hitch. A long pole and a two-horse evener is the standard equipment for a horse-drawn manure spreader. The only change necessary, however, to operate it with a tractor is to put in a short, stub pole. A stub pole, or tractor hitch, of this type is usually designed so that it may be adjusted to suit the height of the tractor drawbar.

Brake. A brake is very desirable in hilly sections and makes it easy to fertilize fields that would otherwise be diffi-

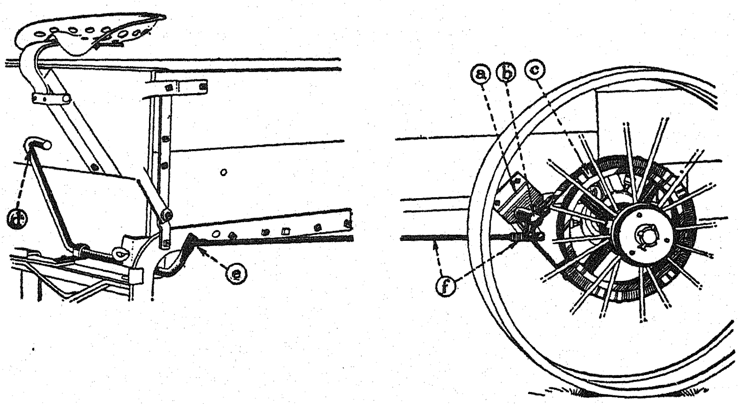


FIG. 223. Construction of brake.

cult. Reference to Fig. 223 will show how the brake is installed. A friction wheel is attached to the main axle, and a friction band is placed over this wheel. The band (*c*) is operated by the rod (*f*), and the connection (*b*). These brake-operating parts are bolted to the main frame by means of the bracket (*a*).

Lime-sowing Attachment. Distribution of lime over a strip 10 to 20 feet wide may be accomplished with this attachment. The lime is unloaded by the spreader apron onto veined distributor wheels. A rear endgate is desirable to retain the lime when traveling to the fields. In some designs a rack or grate of steel bars is used to break up the lime before it falls to the steel distributing wheels. The rate of distribution may be regulated by the setting of the feed lever and the rear endgate (see Fig. 209).

JOB 17

TO REPAIR A MANURE SPREADER

1. Get owner's report on the condition of the machine, broken or worn parts, faulty adjustments, field troubles, etc. Secure the appropriate repair catalog and instruction book.

2. Test and inspect all parts. Block up the spreader so the rear wheels are off the ground. Put it in gear and test the action of the working parts by turning one rear wheel. Then remove the rear wheels to give access to apron and beater driving parts. Test the bearings of all shafts and axles.

3. List the repair operations necessary.

4. Order repair parts.

5. Examine pawls and springs. If the driving edges have worn down to a round edge, replace them with new ones. Worn pawls or broken or weak pawl springs cause much trouble. Test the tension of all the pawl springs.

6. Adjust and repair apron and shafts. While the rear wheels are off it is easy to get at the apron-driving parts. Examine the feed pawls. It is usually advisable to replace these parts. Test the tension of the feed-pawl springs. Replace them if necessary. Clean out all the teeth on the ratchet wheel and wash it off with kerosene. Inspect the bearings of the apron shafts. Clean off any dried grease or other accumulation. Replace the bearings if necessary. Make sure that the grease tubes leading to these bearings are open. Examine the bearings

of the front conveyor shaft or sprockets. Clean out the oil holes.

Inspect the links of the conveyor chain and replace worn links. Tighten any loose connections between the conveyor slats and the conveyor chain. Adjust the tension of the apron. Straighten the conveyor slats.

7. Repair beaters. Examine carefully all the bearings on the shafts and wide-spread device. Clean them thoroughly with kerosene. Often the ends of the beater shafts will be found wrapped with straw.

Beater teeth become bent and loosened. They must be straightened out and secured tightly in the beater bar.

Remove the beater drive chain. Wash it out thoroughly by immersing it in kerosene. Replace badly worn links. Then immerse the whole chain in oil. Used crankcase oil from tractors or automobiles is suitable for this purpose.

8. Repair front truck. Jack up the front end of the spreader until the front wheels clear the ground. Remove the front wheels and examine the bearings. These are likely to show considerable wear, particularly if they have not been well lubricated. Clean and adjust the front wheel bearings. Replace the pivotal axles if necessary. Tighten the bearings of the pivotal axles in the front bolster. Adjust the drag links so that the wheels toe in slightly.

9. Paint and reassemble. Painting is very desirable, particularly for the wooden parts of the spreader box. The pole also should be painted or given a coat of linseed oil. Metal parts should be painted to prevent rusting.

CHAPTER IX

THRESHERS AND COMBINES

Although the number of harvester-threshers, or *combines*, increases each year, the stationary type of threshing machines is still widely used. The grain is hauled to it and the threshing is done with the machine "set" in one place. The straw is piled or stacked at the rear of the machine. The grain is either

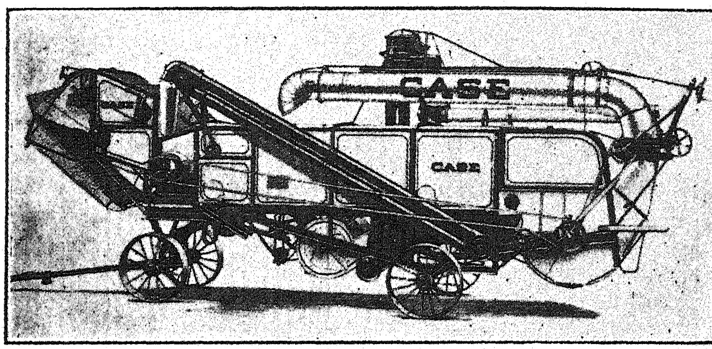


FIG. 224. Modern type of thresher.

sacked at the machine or hauled away in large wagon boxes. The thresher is mounted on a truck so that it may be moved easily (Fig. 224).

Combines, which both harvest and thresh the grain as they are drawn through the field, combine the work of the binder and thresher. They have been improved and developed greatly during the past decade. Combines have been made for many years but until recently they were of large size, suitable for use on large ranches rather than on the family farm. Now, units cutting a 40-inch swath are available.

Threshing machines should remove all the kernels from the

head and separate all chaff, straw, weed seeds, etc. They are in reality grain-threshing and grain-cleaning machines. One part of the machine threshes, another separates the grain from the straw, and a third cleans the threshed grain. The whole process is well described by the expression "separation"; hence these machines are often called *separators.*

Stationary threshing machines are belt-driven. They must receive power from some outside source such as steam engines, gasoline or kerosene engines, farm tractors, and, in some districts, electric motors.

Sizes. The size of a threshing machine is expressed by stating the length of the cylinder (Fig. 226*a*), which is at the front of the machine, and the width across the separating and cleaning parts, straw racks, sieves, etc., which are at the rear of the machine. These sizes are expressed in inches. A 20 by 36 grain separator has a cylinder 20 inches long and a separating mechanism 36 inches wide. This is considered a small machine and would require a farm tractor of about 18 belt horsepower to operate it successfully. A 40 by 62 thresher with self-feeder and wind stacker is about the largest size made. This would require about 60 belt horsepower for successful operation. The weight of the machines in the smaller size mentioned averages about 5000 pounds. Threshers 40 by 62 weigh approximately 10,000 pounds.

Construction and Principal Parts

Feeder (Fig. 225). The feeder conveys the bundles of grain into the machine. It also cuts the twine bands on the bundles and delivers the bundles to the cylinder in a steady, even flow. All parts of the cylinder should receive the same amount of straw, the outside ends as much as the center. In other words, the bundles should be spread out and fed evenly.

1. *Feeder Raddle or Conveyor Canvas* (Fig. 225*a*). This carries the bundles into the machine. It is equipped with sideboards (*b*) which prevent the bundles from falling off. The

bundles should be pitched onto the conveyor with the heads toward the cylinder.

2. *Knives.* The revolving knives (*c*) cut the twine on the bundles and spread and straighten the straw. The knives are kept clean and the straw is prevented from winding up on them by means of the stripping bars (*d*) between which they revolve.

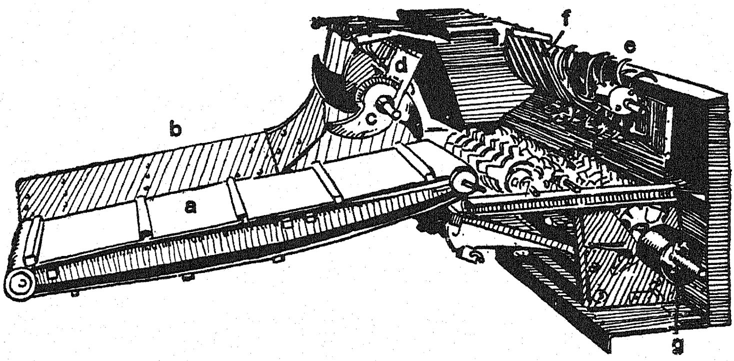


FIG. 225. Construction and principal parts of feeder.

3. *Spiked Roller.* The spiked roller shown at *e* feeds the grain downward to the front of the cylinder. The bars (*f*) prevent the spiked roller from clogging.

Many self-feeders are controlled by governors. If the rate of feeding becomes heavy enough to materially decrease the cylinder speed, the action of the governor automatically stops the conveyor. No more bundles are fed in until the normal cylinder speed is regained.

Small threshers are not usually equipped with self-feeders. The bundles are cut and fed to the cylinder by hand.

Cylinder (Fig. 226). Threshing the kernels of grain from the heads is accomplished by the action of the cylinder teeth (*a*) and the concave teeth (*g*). The parts of the cylinder are as follows:

1. *Cylinder Bars.* The cylinder is made up of from nine

to twenty parallel bars, each bar carrying a row of cylinder teeth.

2. *Cylinder Shaft.* The central shaft of the cylinder (*b*) is large and heavy and made of high-grade steel. It is the main drive shaft and transmits power to all other parts of the machine. The main drive pulley is mounted on the cylinder

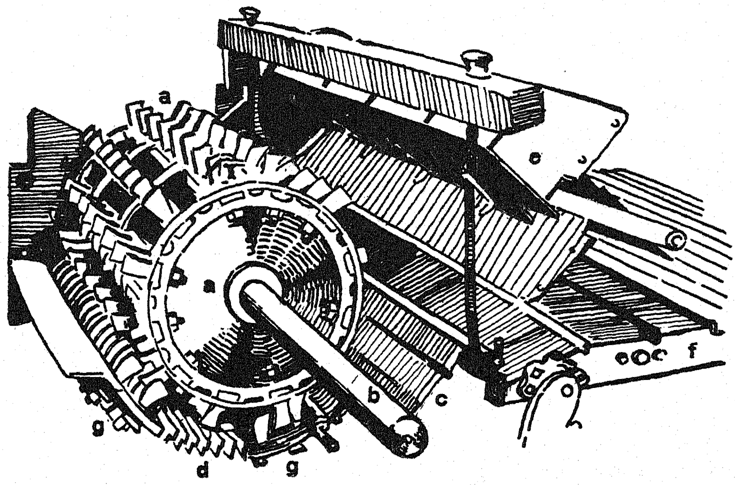


FIG. 226. Construction of cylinder and concaves.

shaft. This pulley is driven by a long belt from the source of power.

The speed of the cylinder varies in various sizes of machines from 750 to 1200 revolutions per minute. This gives a speed at the circumference of the circle, made by the cylinder teeth, somewhat greater than a mile per minute. If the speed becomes too high, the kernels will be broken; if too low, not all will be removed from the heads.

3. *Cylinder Bearings.* Because of its high speed and heavy load, the cylinder must have sturdy bearings, designed for easy and thorough lubrication. A babbitt-lined cylinder bearing with oiling device is commonly used. This bearing is pro-

vided with an oil ring which aids in distributing oil to the entire surface of the bearing.

Ball bearings are also used on the cylinder shaft. The balls are packed in grease and enclosed in a dust-proof housing. A grease fitting is also provided for additional lubrication.

A special grade of heat-resistant lubricant is required for the cylinder bearings.

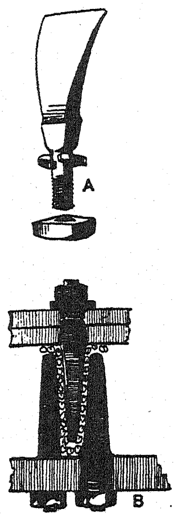


FIG. 227. Detail of concave and cylinder teeth.

Concaves. The concaves are flat bars of iron which extend across the machine just below the cylinder. They are so called because the bars are slightly concave to correspond to the shape of the cylinder which revolves above them. Figure 226*g* shows the location of the concaves. Each concave carries two rows of teeth which are driven into the concave and secured with a nut on the underside. The concaves are stationary. The cylinder teeth revolve between the concave teeth. In Figure 227 the concaves are correctly adjusted. Often the concaves are too far away from the cylinder teeth, permitting whole heads of grain to pass through unthreshed.

The concaves are held in place by hangers and may all be adjusted as a unit. Adjustments are also provided for moving either the concave or the cylinder sideways. Correct adjustment of the concaves is essential to good threshing. The cylinder teeth should pass through the center of the space between the concave teeth.

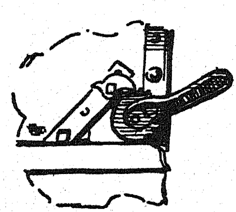


FIG. 228. Adjustment for setting concaves.

The number of concaves to use depends upon the kind and condition of the grain being threshed. One concave is generally used for threshing oats under ordinary conditions.

As many as three concaves (six rows of teeth) may be necessary for difficult threshing such as flax which is not well dried. The rule should be to use the smallest number of concaves that will thresh all the kernels from the heads. Each additional row of concave teeth adds to the load and consumes more power.

Grates (Fig. 226*c*). The grate extends upward at the rear of the cylinder. Grates that are interchangeable with the concaves are also used. These are called *concave grates* (*d*). When a concave is removed a concave grate is put in its place. The proper placement and arrangement of the concaves and grates will be discussed on p. 324.

Separation of the grain from the straw is largely accomplished by the grates at the rear of the cylinder. The kernels of grain sift through the grates and drop to the grain pan (Fig. 230). The straw cannot pass through the narrow bars of the grates; it is directed up the grate and back to the straw rack (Fig. 229) by the action of the cylinder and the beater.

Beater. The location of the beater is shown in Fig. 226*e*. As the beater revolves it directs the straw downward to the straw rack. It prevents the straw from winding on the cylinder and spreads it over the full width of the straw rack.

Straw Rack (Fig. 229). The location of the straw rack is also indicated in Fig. 226*f*. Its function is to convey the straw

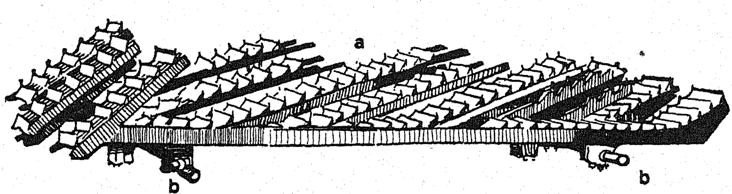


FIG. 229. Straw rack.

to the rear of the machine and to shake or agitate it, thus separating all the grain. To accomplish this, straw racks are given an oscillating motion by means of a crank shaft.

The notched fingers, called *fish backs*, on the straw rack

throw the grain upward and gradually work it to the rear of the machine. This thorough shaking of the straw separates all the grain from it. The grain falls through the open spaces in the straw rack to the grain pan.

Grain Pan and Chaffer (Fig. 230). The grain pan is located directly below the straw rack. It extends from the front of the cylinder well toward the rear of the machine. As the grain is threshed out by the cylinder and is further separated by the action of the grates and straw rack, it falls to the grain pan. The motion of the grain pan is balanced with that of the straw rack. The straw rack has longer lever arms and consequently it oscillates through a longer stroke than the grain pan. When both are loaded they will be more accurately balanced than when the machine is empty.

The motion of the grain pan works the grain backwards. The rear of the grain pan has an adjustable sieve called the *chaffer* (*b*). The chaffer has large openings which allow all but the coarse straw or unthreshed heads of grain to drop through, down to the sieves of the cleaning mechanism.

Chaffer Extension (Fig. 230*c*). The chaffer extension is a short, adjustable sieve with large openings. Its function is to

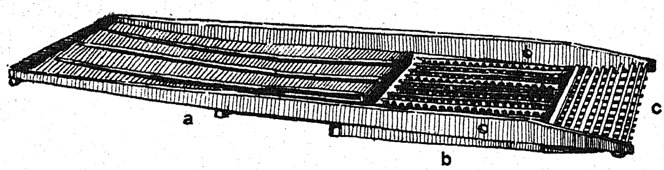


FIG. 230. Grain pan, chaffer, and chaffer extension.

carry straw or coarse chaff from the grain pan and chaffer back to the stacker. Some straw and chaff always sift through the openings in the straw rack and drop to the grain pan with the grain. The chaffer and chaffer extension should carry this back to the stacker but should allow any grain to drop through the openings provided (*b* and *c*).

Many unthreshed heads and kernels of grain, mixed with chaff, reach the chaffer extension. The openings in this should be adjusted to a size large enough to allow such material to pass through and not be carried out with the straw.

Tailings Auger and Tailings Elevator. The tailings auger (Fig. 231*a*) is placed directly below the chaffer extension. Unthreshed kernels and chaff drop through the openings of the chaffer extension into this auger or conveyor. The tailings auger carries the chaff and unthreshed grain to the tailings elevator, which returns it to the cylinder for rethreshing.

The tailings auger and elevator thus provide a means for running the tough heads of grain through the machine twice. This saves grain which would otherwise be lost in the straw.

Cleaning Device or Fanning Mill. The cleaning device, or fanning mill, cleans the grain from the light chaff, weed seeds, etc. It consists of three main parts: the shoe, the sieves, and the fan.

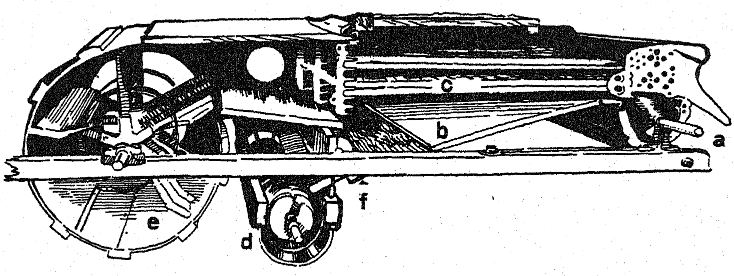


FIG. 231. Cleaning device.

1. *Shoe.* The location of the shoe is shown in Fig. 231*b*. It is given a shaking motion by a pitman. This causes the kernels of grain to be shaken through the sieves which are mounted above the shoe.

2. *Sieves.* Adjustable sieves, located as shown at *c*, are the type commonly used in modern threshers. The size of the open-

ing is adjustable, so that the same sieve may be used for various kinds of grain.

The grain sifts through the holes in the sieve and drops down to the inclined bottom of the shoe. It slides down the bottom of the shoe (which with the sieves is constantly shaken back and forth by the pitmans), into the grain auger or conveyor (*d*). This extends across the bottom of the shoe and carries the grain to the grain-handling device where it is put into bags or wagon boxes.

3. *Fan.* The fan is located as shown at *e*. It extends across the entire width of the machine, and directs an equal draft of air through all parts of the shoe. This draft of air plays against the underside of the shoe sieves (*c*), the chaffer, and the chaffer extension. It blows the light straw and chaff into the stacker, but the heavier grain sifts through the sieves and slides down the inclined sieve to the grain auger.

Chaff, straw, and unthreshed heads of grains that reach the shoe sieve (*c*) are blown off the rear end of the sieve into the tailings auger (*a*) and returned to the cylinder for rethreshing.

Under certain conditions it is necessary to use a weed screen[1] (*f*) in the bottom of the shoe. This allows the small weed seeds to pass through and drop to the ground. The grain kernels, being larger, cannot pass through the openings in the weed screen, but slide over it to the grain auger (*d*).

Good threshing requires careful adjustment of the cleaning device. The amount of air used through the shoe, the size of the openings in the shoe sieve and chaffer, the angle of the chaffer extension, etc., are all adjustable. Directions for making these adjustments are given on p. 326.

Straw Stacker (Fig. 232). Two types of straw stackers are in common use—the straw carrier and the wind stacker.

The straw carrier is much the same in general construction as the web carrier used on the self-feeder. It elevates or car-

[1] A screen lets refuse, such as small weed seeds, pass through it but the grain passes over it; a sieve lets the grain pass through it but straw and chaff pass over it.

ries the straw away from the machine. Straw carriers are used on the smaller sizes of threshers.

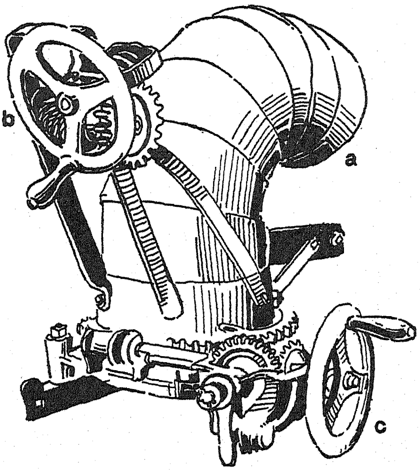


FIG. 232. Straw stacker or blower.

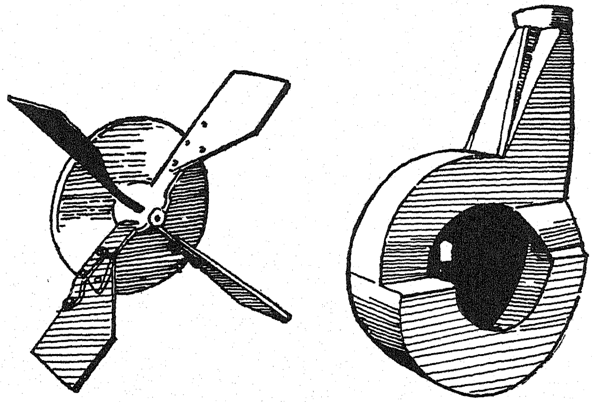


FIG. 233. Straw-stacker fan and fan housing.

Wind stackers are used on the larger-sized threshers. They are sometimes referred to as *blowers*. They consist of a large

fan (Fig. 233) and a large adjustable pipe. The end of the pipe is fitted with an adjustable hood. The fan is mounted inside the housing.

Wind stackers are provided with adjusting cranks (*b* and *c*) for raising or lowering the pipe and for swinging it from side to side. By means of these cranks a large stack of straw may be made without changing the position of the thresher. When not in use, the wind stacker may be folded back over the thresher.

Grain-handling Device (Fig. 234). The threshed and cleaned grain slides down the inclined bottom of the shoe to the grain auger which carries it across the machine. On small threshers it is caught in baskets at this point. On larger machines, however, this process would be too slow and laborious. Hence, grain-handling devices are used which require a minimum of labor in handling threshed grain.

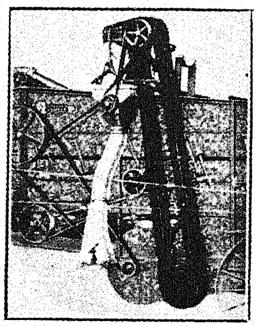


Fig. 234. Grain-handling device.

A commonly used grain-handling device consists of an elevator, on the inside of which a chain with cuplike receptacles carries the grain upward to the weigher. The weigher is a metal basket that dumps automatically when a certain weight of grain has entered. The weigher basket is provided with a scale and may be adjusted to dump when exactly the proper weight has entered it. This weight will vary, of course, for the different kinds of grain; hence, the careful adjustment of the weigher is necessary. Each time the weigher trips it registers on a meter, automatically recording the number of bushels threshed.

When the weigher dumps, its load is delivered to the bagger spouts, at the bottom of which holders for two bags are pro-

vided. Two are necessary in order that one may be filled while the other is being taken off, tied, and placed on the wagon.

Grain spouts for loading the grain loose in wagons are often used instead of baggers.

JOB 18

TO REPAIR A THRESHING MACHINE

1. Get owner's or operator's report on the condition of the machine, broken or worn parts, faulty adjustments, operating troubles, etc. Secure the appropriate repair catalog and operator's instruction book. Ascertain the year of manufacture and obtain other helpful information.
2. Test and inspect all parts. Operate the machine idle at the recommended cylinder speed and work out accumulated strain and chaff. Test the speed of all shafts. Open top doors and get good light. Test all bearings, hangers, pitmans, belts, and working parts as indicated below.
3. List the repair operations needed.
4. Order repair parts.

Description of Usual Repair Operations

1. Replace broken slats in the feeder carrier. See that the canvas is properly attached to the slats and that the leather straps, if used, are in good condition. Replace feeder sideboards if necessary.
2. Sharpen the band knives; replace broken knives.
3. Clean and adjust the cylinder-shaft bearings. Provide new bearings if necessary. See that the grease tubes leading to these bearings are clear.
4. Replace worn cylinder teeth. This must be done every season if the thresher is used for custom work. Worn cylinder and concave teeth make the load heavier and cause a loss of power. When new teeth are put in, it is necessary to drive them in firmly with a hammer and then tighten the nuts. All the teeth should be gone over with a heavy hammer several times. Each time they may be drawn a little tighter. It is pos-

sible to detect a loose tooth by the sound it gives when struck with a hammer.

5. Take the "end play" out of the cylinder. A special adjustment is usually provided for this purpose, near one of the cylinder-shaft bearings.

6. Replace broken or worn concave teeth. To do this the concaves are removed from the machine. Tap the new teeth down well with the hammer, and tighten several times. When tightening the concave teeth with the hammer, do not strike as heavy blows as on the cylinder teeth. The concaves are cast iron and are likely to break. The bars of the cylinders are steel.

7. Take up the bearings between the studs and rocker arms that drive the straw rack. These rocker arms serve as hangers for the straw rack.

8. Examine the bearings of the straw-rack cranks and take up any wear or looseness. See that the oil passages leading to these parts are open.

9. Adjust the bearings of the pitmans that drive the straw rack. These bearings are usually adjusted with setscrews or bolts. If two pitmans are used, they must be kept exactly the same length.

10. Move the grain pan back and forth and see that it works freely. Examine the bottom and sides, and replace any broken sections. Canvas or wood guides are provided between the stationary sides of the thresher frame and the moving grain pan. These should be gone over carefully and tightened or replaced as required, to prevent grain from leaking out.

Adjust the bearings of the grain-pan hangers, or put in new hangers if they are badly worn. The hangers must be adjusted equally on both sides so that the grain pan will hang level.

11. Inspect the chaffer and chaffer extension. See that all parts are in good condition. Tighten the connections holding the chaffer to the grain pan.

12. Examine all parts of the cleaning device.

(*a*) See that the screen adjusters work freely.

(*b*) Test the bearings of of the shoe pitmans and adjust them properly. (Both shoe pitmans must be of equal length.)

(*c*) Repair the sieves and sieve frames as required. The frames must be straight, the corners tight, and the metal of the sieves free from breaks or tears.

(*d*) Adjust the fan bearings to take up the wear. (Remove shims as required.)

(*e*) Examine the fan blades. Replace any that are broken. Tighten the rivets or put new rivets into blades that are loose. See that the fan blades revolve without striking.

13. Revolve the grain auger and tailings auger to see that they turn freely.

(*a*) Examine the troughs that surround these augers. These troughs are made of sheet iron and should be protected from rust.

14. The tailings elevator or carrier may be made of steel cups or of small wooden slats, mounted on a long chain or web. This may be disconnected so that the entire elevator may be pulled out for inspection. Broken cups or slats should be replaced. The bearings for the shafts at the top and bottom of the tailings elevator should be adjusted. Then the carrier may be replaced and drawn up tight enough to prevent slippage.

15. Test the grain elevator and adjust the bearings at the upper and lower ends, as required. Examine the chains and cups of the grain elevator. Test the weigher basket and see that it trips properly. Straighten the grain spouts and bagger parts, as required.

16. Adjust the bearings on the end of the shaft of the wind stacker to take up looseness. (This may be done by removing shims.)

(*a*) Test the fan blades and spiders of the wind-stacker

fan in the same manner as the grain-cleaning fan. Revolve the fan and see that none of the blades strike. The fan blades must be of equal length and weight in order that the fan may balance properly. If one side (or blade) is heavier than the other, it will not run properly at high speed.

(*b*) Examine the lifting and swinging adjustments on the wind stacker, and see that they function properly.

(*c*) Straw carriers frequently require new sideboards and bottomboards. In addition, the following will need careful attention and adjustment: carrier slats; carrier rollers and the bearings of such rollers; and elevating or raising mechanisms for the straw carrier.

17. Lubricate thoroughly all bearings in all parts of the thresher. A sharp wire hook will be useful in this work for cleaning out oil holes. All lubrication fittings should be carefully tested.

The axles of the truck wheels must also be lubricated.

Operating a Threshing Machine

Lubrication. Selection of the correct grades and qualities of lubricants is especially important. Both a fluid oil and a semi fluid, or soft grease are usually required. Lubrication instructions contained in the appropriate operator's instruction book should be followed carefully.

1. Locate all grease fittings or oil holes on the feeder. Clean out the oil holes and oil each one thoroughly. Refill all the grease-cup caps, if present, and turn them down several times. Force grease in through fittings until the excess flows from the bearings. This will clean the bearing.

2. Remove the grease-cup caps on the cylinder bearings. Refill and turn them down several times. (If compression grease-gun fittings are used, force grease in until an excess can

be noted. Some cylinder bearings have oil cups instead of grease cups. Fill these with oil.) The cylinder bearings require a high-grade lubricant. Do not use cheap axle grease on them. Consult the instruction book.

3. Grease or oil all shafts, cranks, or bearings on the left side of the thresher. Note each place and remember the number of places to be lubricated.

4. Grease or oil all places on the right side of the thresher. Remember the number of places to be lubricated. Should these places be oiled when the machine is in operation?

5. Lubricate all parts on the straw stacker, including the raising and oscillating cranks.

6. Oil lightly the parts of the tripping mechanism of the weigher and meter.

7. Grease the axles of the truck.

8. Keep the supply of oil and grease that is carried with the thresher free from dust and chaff.

Setting and Lining Up. Set the thresher level both lengthwise and crosswise. If the machine is low in the front, the grain will pile up on the grain pan and not move backwards to the sieves.

Block the wheels to prevent the machine from being drawn forward by the belt.

Put on the drive belt and draw it tight enough to prevent slippage.

A good alignment of the driving pulley of the power unit and of the driven pulley of the thresher cylinder is necessary to keep on the belt. This is particularly necessary in windy weather. A poor alignment may also cause the sides of the drive belts to rub on the belt guides and wear rapidly.

If possible, the machine should be set so that the wind, if any, blows from the power unit in the general direction of the thresher. This results in keeping the operators out of the dust as much as possible. The most favorable setting is to have the wind on the quarter.

Threshers are driven from the source of power (steam, engine, farm tractor, or electric motor) by a long belt. This is called the *drive belt.* Drive belts are made in widths from 5 to 9 inches, and are furnished in lengths from 40 to 150 feet.

The drive belt is placed over the large pulley on the thresher cylinder. This is the main drive pulley of the thresher, and from it power is transmitted by belts to all other parts. (See Fig. 225*g*.)

Adjust concaves and sieves. Make the concave and sieve adjustment suitable for the grain to be threshed, according to the following directions.

The number of concaves used depends upon the kind and condition of the grain. The rule is to use as few rows of teeth as possible and still secure thorough threshing. Set the concaves close enough to prevent the grain heads from passing through unthreshed.

If too many rows of concave teeth are used or if they are set too close, the straw will be chopped up very fine. This will tend to overload the cleaning sieves or clog them up. It is very difficult to secure well-cleaned grain under such conditions. Refer to the manufacturer's instructions for recommendations.

Testing Speeds. Before putting on any of the thresher belts, let the drive belt turn over the cylinder only, for a short time, to see that the teeth are properly spaced and that none strike.

Put on all the belts and run the machine slowly for a short time.

Turn down the grease cups and fill all the oil holes while the machine is running. While this is being done, any part that is not functioning properly will be noticed.

Run the machine at full speed for a few minutes. Check the speed of the cylinder. See that all belts are tight enough to prevent slippage. If they are not, some parts will not run at the proper speed.

The cylinder must revolve at the proper speed to do good

threshing. The speed of the cylinder in small threshers should be about 1075 revolutions per minute. The speed of the cylinders in large machines is 750 to 800 revolutions per minute. The operator should know the correct speed and should be able to determine the exact speed with a speed indicator or revolution counter. It is essential that the cylinder be driven at the proper speed because all the other parts are driven from it. If the cylinder speed slackens, the speed of the other parts decreases and clogging may result.

Keep constant watch on the grain. Change adjustments as required to have it well cleaned.

Examine the straw to determine if any grain is going through the machine unthreshed. Change adjustments as required to get all kernels threshed out of the heads. The adjustment of the parts mentioned in the following paragraphs should be changed as required, to get a satisfactory job of threshing and cleaning.

Straw Grate. The straw grate at the rear of the cylinder is adjustable in some machines. It should be kept as high as it can be and still let the straw pass through freely. The grain is separated from the straw more easily with the grate high.

Beater. The operator should make sure that the beater is well secured to the shaft on which it is mounted. The setscrews securing it to the shaft should be kept tight. Some machines provide a means by which the beater can be raised to a higher position for threshing very tough grain. The beater should be exactly centered between the two sides of the machine.

Straw Rack. To do good work, the straw rack must vibrate at the proper speed. This varies on different machines, but an average rate is 200 vibrations per minute. The belt driving it must be kept tight with no slippage permitted. The bearings of the crank and pitmans must be adjusted properly or else knocking and pounding will result. Both pitmans must be of the same length or else the straw rack will be twisted out of shape.

Grain Pan. Grain is sometimes lost between the sides of the machine and the grain pan. Shields or canvas coverings are

used to prevent this. They should be carefully watched to see that no leaks of grain occur.

Chaffer. The sieve of the chaffer should be opened wide enough to let all the good grain through to the sieves in the fanning mill. Any grain that passes over the chaffer either is lost entirely or else drops through the sieve of the chaffer extension and returns to the cylinder through the tailings elevator.

Chaffer Extension. The openings in the chaffer extension should be made much larger than those in the chaffer.

Fanning Mill: Sieves. The position or angle of the sieves used in the cleaning shoe is adjustable, as is the size of the openings in the sieve itself. The size of the opening should be large enough to let all the grain through readily.

The sieve is usually placed in the shoe with a slight angle downward, toward the fan and grain auger. Under favorable conditions the sieves can be placed nearly level.

The more nearly level the sieve is, the less readily large particles of chaff and dirt fall through the screens. For cleaning dirty grain, a heavier blast of air can be used without the grain's being blown out, if the sieves are set with the front end low and the rear end high.

Tailboard. The tailboard at the end of the chaffer extension should be raised, if necessary, to prevent the grain from being blown out into the stacker.

Air Blast. The amount of air used can be regulated by raising or lowering the doors at the side of the fan housing. The fan must be kept tight on the fan shaft, and the fan belt must not slip. If the fan does not run fast enough, the threshed grain is often found to be dirty. The blast of air should be strong enough to carry off all the chaff, but not so strong that it blows away the kernels of grain. It should be equally strong on all parts of the sieves. To get an even blast, the doors on each side of the fan housing must be opened equally.

Weed Screen. Screens function in a manner opposite to that of the sieves. The openings in the sieves are large enough to

allow the good grain to pass through. The openings in the weed screens are very small; they exclude the good grain but allow the small weed seeds to pass through.

Weed screens are clamped in the bottom of the shoe. They are not adjustable. Weed seeds and other foreign matter (called screenings) fall through the screen to the ground.

Common Troubles

Some of the more common threshing troubles, with their causes and remedies, are given below.

Cracked or Broken Kernels

(*a*) Uneven spacing between cylinder teeth and concave teeth.
(*b*) End play in cylinder.
(*c*) Cylinder running too fast (particularly in very dry grain).
(*d*) Uneven feeding.
(*e*) Too many rows of concave teeth.
(*f*) Concaves set too close to cylinder.
(*g*) Threshed grain returns to the cylinder and is cracked when rethreshed.

Grain that is properly threshed may return through the tailings elevator if the openings in the chaffer and chaffer extension are not large enough. (See trouble 3 below.)

Grain Is Not Threshed Properly from Heads

(*a*) Cylinder speed too slow.
(*b*) Not enough rows of concave teeth.
(*c*) Concaves set too wide.
(*d*) End play in cylinder shaft.
(*e*) Worn concave teeth or worn cylinder teeth.
(*f*) Feeding too fast.
(*g*) Tough or wet straw.

The remedy for each of the above is implied in the cause of the trouble. Feeding the cylinder requires care and constant

attention. The grain should be fed in with the bundles lying straight. The heads should enter the cylinder first. Too rapid feeding or bunching of the bundles on the feeder web or raddle may clog up the machine.

Too Much Tailings (Tailings Elevator Returns Too Much Material to the Cylinder)

(*a*) Overloading (feeding too rapidly).
(*b*) Speed too slow.
(*c*) Too many rows of concave teeth, or concave teeth set too close. This chops up the straw, and a heavy load is thus placed on the chaffer and sieves. Much of this returns through the tailings elevator.
(*d*) Too strong an air blast. (This will cause much of the grain to be blown into the tailings auger and returned to the cylinder.)
(*e*) Openings in chaffer and shoe sieve too small. To remedy, correct whichever one of the above causes is responsible for the trouble.

Grain Is Not Well Cleaned

(*a*) Openings in chaffer sieve or shoe sieve too large. This allows many particles of foreign matter, joints and straw, etc., to pass through the sieve openings and reach the grain auger with the grain.
(*b*) Air blast not properly adjusted—enough wind must be used to blow out the chaff. The current of air must be directed against all the under surface of the shoe sieve, not against the center portion only. An adjustable windboard is provided in some machines for this purpose.
(*c*) Agitation (shake) of the shoe not sufficient, owing to a slipping belt or to shoe pitmans that are not properly adjusted.
(*d*) Weed seeds in the grain. This is caused by the weed screen's not being in its proper place in the bottom of the shoe; or, as often happens, the weed screen may be plugged.

Combines

Harvesting and threshing simultaneously eliminate many expenses, such as binding, shock, pitching bundles, and hauling to the thresher. Less labor is required and less inconvenience results; the grain is not subjected to many separate handlings, and accordingly there is less loss of grain in the field. Another distinct advantage is that fields are ready for the plow as soon as the combined operation is completed.

Some of the disadvantages are: the grain must be left standing until fully ripe, then being exposed at such a critical time to damage by storms; weeds seeds are permitted to ripen; extra operations are required to save the straw; nor is it convenient to cut as much of the straw as with a binder.

Types and Sizes. The larger sizes, 14 feet cut or wider, are available in the *hillside* type; the thresher may be kept

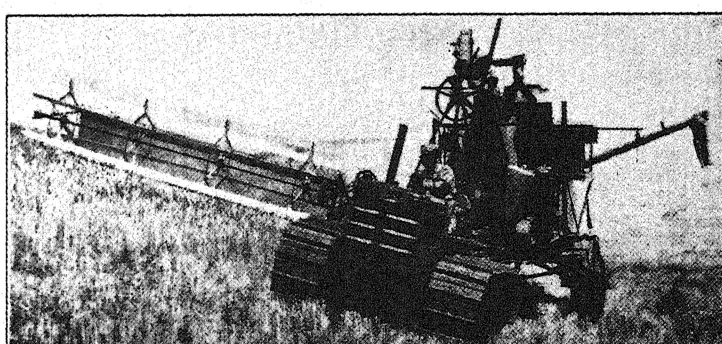


Fig. 235. Hillside combine.

level when working on steep hillsides by raising or lowering the left hand main wheel (Fig. 235).

Units without such a leveling device are designated as the *prairie* type. Most of the smaller sizes are of this type; some have a special hinged platform which permits the header bar to operate at an angle with the thresher.

A further classification might be based on the type of cylin-

der used. The *spike-tooth* cylinder used in threshers is also used in some of the larger sizes of combines. The *raspbar* or *rubbar* cylinder (Fig. 238) is employed in most of the smaller sizes.

The cutter bar is directly ahead of the cylinder and the straw moves in a single direction through the entire machine

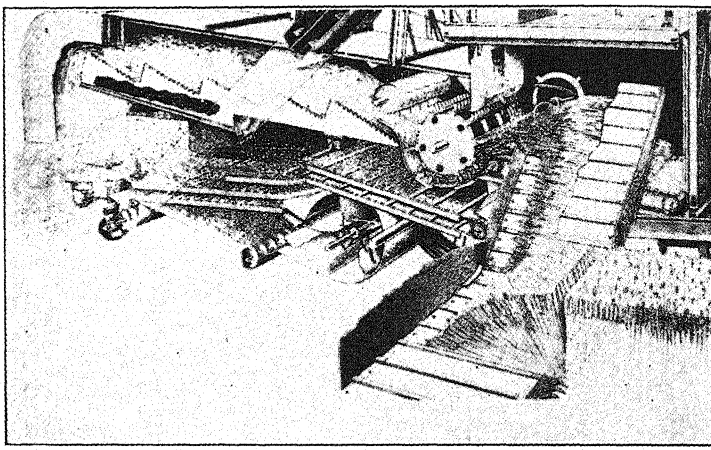


FIG. 236. Interior view of combine with cutting unit set at a right angle with the threshing unit.

in the smaller sizes. But the width of the cutter bar in large units makes this construction impractical, and the cutter bar is placed at one side of the thresher unit. In these types, the platform conveyor receives the cut grain and carries it to the feeder conveyor, which carries the grain to the cylinder. These two conveyors are at right angles to each other, as shown in Fig. 236. In the largest sizes the thresher is placed crosswise behind the cutter bar, as the length of the threshing unit is nearly the same as the width of cut.

Combine sizes are designated first by the width of cut and also by the width of cylinder and the separating mechanism.

The smallest size now available cuts a 40-inch swath and

weighs approximately 1700 pounds. Many sizes are available, 5 feet, 6 feet, 8 feet, 10 feet, 12 feet, 14 feet, and 16 feet being common sizes. A typical 16-foot-cut model with auxiliary engine weighs approximately 9000 pounds.

Construction

Cutting (Fig. 237). The cutting mechanism is quite similar to that of binders, and the description given in Chapter

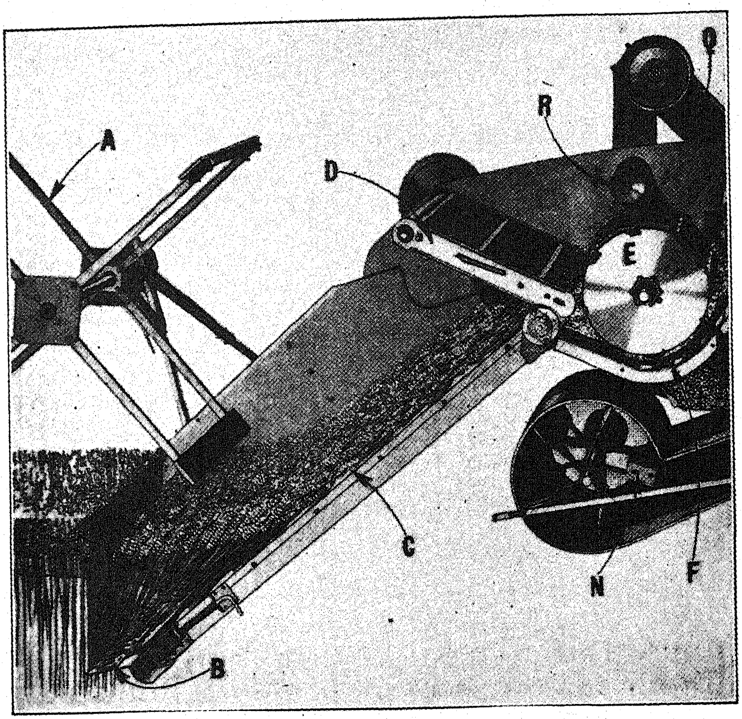


FIG. 237. Front half of small combine.

VII will be applicable, in general, to the cutter-bar construction of the combine. Provision is made for wide range of adjustment in the height of cut. It may be varied from 2 or 3 inches to 3 or more feet above the ground. This wide range is necessary

because farm practices vary. Some practices provide for leaving all the straw on the field, and others endorse saving the straw and using it for other purposes. The wide variety of grain crops and special seed crops harvested with combines

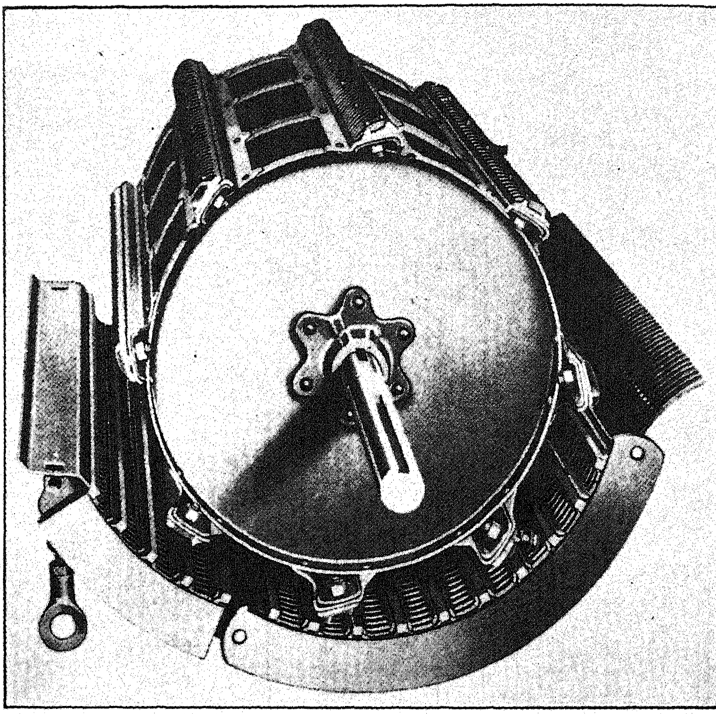


FIG. 238. Raspbar or rubbar cylinder with concaves.

necessitates many different adjustments in the height of cut. The cutting unit is supported and balanced so that it may be tilted or raised easily with a hand lever or wheel.

The cutting unit includes the reel (*A*), the cutter bar and sickle (*B*), and the platform and canvas (*C*). The platform canvas, in connection with the feeder conveyor (*D*), feeds the grain evenly into the cylinder (*E*).

Threshing. The spike-tooth cylinder and concaves are the same as those used in threshers. The raspbar or rubbar type is illustrated in Fig. 238. The cylinder carries an even number of steel bars with corrugated faces cut diagonally and in opposite directions across adjacent bars. The front of the concave assembly is a solid plate to which the concave bars are bolted. The rubbing or rasping which threshes the grain takes place between the cylinder bars and the solid concave bars. The concave grates, with large openings, are placed behind the concave bars. The steel fingers supplement the grates in permitting threshed grain to fall through these openings into the grain pan below.

Rubber is used on the faces of the cylinder and concave bars in some models. These are termed *flail bar cylinders* because the action is similar to that of a flail.

Separating. The course of the straw through a typical combine may be followed in Figs. 237 and 239. Threshing the grain from the heads is accomplished at the cylinder (*E*). Probably 75 per cent of threshed grain is separated from the straw at the concaves (*F*), where it sifts through the grates directly to the grain pan (*K*). But some grain is still mixed with the straw leaving the rear of the cylinder. This is pressed down against the straw rack (*I*) by the beater (*G*). The front end of this straw rack is fitted with a chaffer section, and the rear end with large cells through which grain falls to the grain conveyor (*J*). The deflectors (*H*) hold the straw down against the rack and give thorough separation before the straw is delivered from the end of the machine. The grain conveyor carries the chaff and grain forward and delivers it to the grain pan (*K*).

Cleaning. The air blast set up by the fan (*N*) is directed by the deflector (*O*) against the adjustable chaffer (*L*), located toward the rear of the grain pan. The air stream also acts through the shoe sieve (*M*) and blows light chaff and

straw out the rear as shown, but the heavier grain falls through the shoe sieve (*M*) and down to the grain auger (*S*). This carries it across the bottom of the machine to the elevator (*T*), from which it is delivered to a grain tank or bagger attachment.

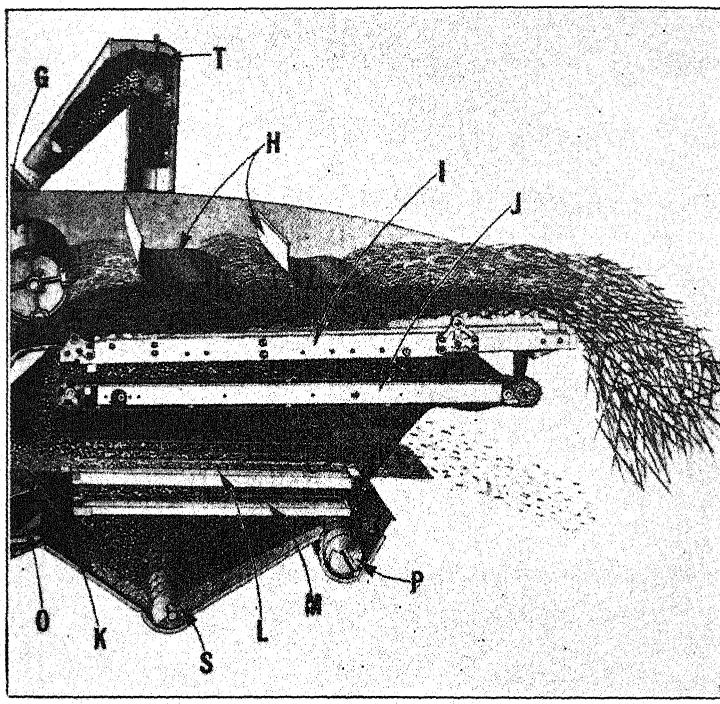


FIG. 239. Rear half of small combine.

Some good grain mixed with chaff is always carried off the rear of the chaffer and shoe sieve (*L* and *M*). This is not blown out at the rear—if the air blast is properly adjusted—but falls to the tailings auger (*P*), which carries it across the machine to the tailings elevator (*Q*), from which it is delivered by the auger (*R*) to the cylinder for rethreshing.

Special Attachments

Pick-up Attachment. This is used for crops that have been previously harvested and windrowed. When crops ripen unevenly and for certain seed crops, it may be desirable to windrow and permit them to fully cure before threshing. The pick-up attachment is also used for crops such as edible peas or beans which shatter easily.

Straw Buncher. This device may be attached in place of the rear hood. Straw accumulates until the unit is full, when the bottom may be tripped to drop the straw in bunches.

Straw Windrower. This attachment piles the straw in windrows so that it may be gathered by the usual hay tools. By shifting the position of the windrower, the straw from the second swath may be piled on that of the previous swath, thus making a larger windrow and lessening the work of collecting the straw.

Straw Spreader. A vane-distributing wheel may be attached to the rear of the thresher unit when the straw is to be spread evenly over the field and plowed under.

Grain-handling Device. Combines may be equipped with a bagger platform and bagging attachment. A two-way delivery spout permits one sack to be filled while the other is being removed and tied. A seat is provided for the operator, and also a chute for sliding the bags down to the ground.

Where loose grain is handled, a grain tank—of a size adapted to the capacity of the combine—is furnished. This is provided with an elevator—driven by power from the tractor—which quickly loads the contents of the grain tank into a wagon or truck.

Special Guards and Lifters. Guards designed for definite field conditions and extensions for lifting lodged and matted crops are available.

Auxiliary Engine. On the larger machines an auxiliary engine is often used to drive the mechanism of the combine, instead of taking power from the tractor. The speed of the combine parts may be kept uniform at all times.

Special Crops. Special equipment and attachments are available for threshing the following crops: soybeans, rice, sorghum, table beans, clover, alfalfa, lespedeza, timothy, peas, vetch, flax.

Rotary Weed Screen. This is located between the grain elevator and the grain tank (or larger attachment). The grain is retained by the small mesh of the cylindrical seed screen and passes on to the grain tank, but weed seeds sift through the screen and are collected in a separate hopper or bag.

Operating a Combine

Many of the suggestions given for operating the binder and thresher may be applied to the combine and need not be repeated here.

Cutting Unit. The assisting springs should be adjusted so the height of cut may be altered easily and quickly. Usually the grain is cut just below the heads, and an accurate quick acting adjustment is necessary to maintain the cutting height. Reducing the amount of straw entering the cylinder simplifies the operations of threshing, separating, and cleaning.

The reel is usually driven by one of the transporting wheels and its speed, therefore, is governed by the forward speed of the combine. The reel speed may be changed by varying the driving sprockets or pulleys. If the speed is excessive, ripe grain may be threshed out by the reel fans; if too slow, cut grain may fall on or ahead of the sickle and choke it. For short crops the reel should set about 4 inches above the cutter bar, and raised higher for taller crops. To pick up lodged grain, the reel should be set low and well forward.

Conveyors. Tension of the platform and feeder conveyors should be just tight enough to prevent slippage. Excessive ten-

sion causes loss of power and rapid wear. Be sure they run square with the frame.

Threshing. Consult the manufacturer's instruction book to find the correct cylinder speed and concave adjustment for the crop to be threshed. Too high cylinder speed may give an excess of chaff and may result in cracking the kernels. Too slow speed will not give thorough threshing. The cylinder should be running at its rated speed before entering the grain; the tractor engine should not be throttled down while grain is entering the cylinder. If rough ground makes it necessary to reduce forward speed, choose a lower tractor speed, but maintain engine speed. Some designs provide an "over-running clutch," which permits reducing the tractor speed momentarily without reducing the cylinder speed.

Cylinder speed is varied by changing the drive sprockets or belt pulleys, or by adjusting the pulleys if V belts are used (see p. 460). Desirable cylinder speeds for different crops vary from 300 to approximately 1600 revolutions per minute; the proper speed is determined by the kind and condition of grain, the amount of straw, and the diameter and type of cylinder, etc.

Cylinder and Concaves. One method of adjusting the distance between the cylinder and concave bars, for threshing different crops, is illustrated in Fig. 240. The cap screws that hold the rubber-covered shelling plate (*G*) pass through slotted holes; so that the distance between the plate and the cylinder bars may be changed to increase the distance between the cylinder bars (*F*) and the concaves (*H*), the four bolts (*A*) are loosened and the cylinder shaft and bearing case are drawn upward by the adjusting bolt (*E*). The same adjustment should be made at each end of the cylinder. The cylinder may be moved forward to give more clearance at the rear (when the crop has heavy weeds) by removing the spacer (*C*) and placing it next to the rear spacer (*B*).

The other method of adjustment consists in moving the concaves toward the cylinder, as explained under threshers (p. 312).

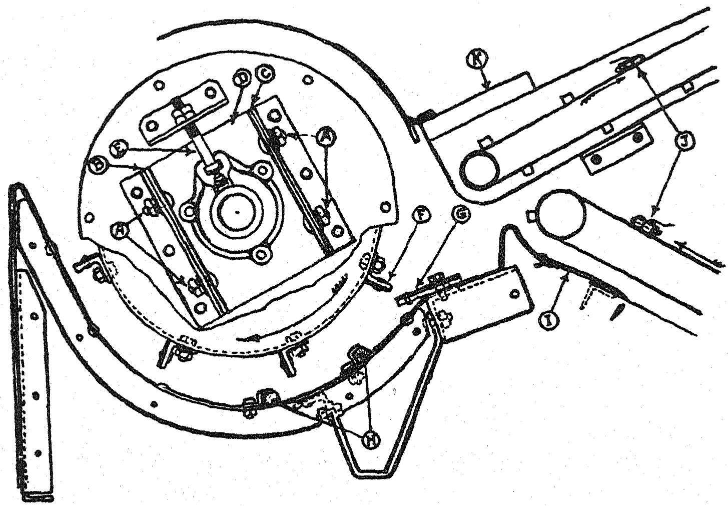


FIG. 240. Adjustment of cylinder and concave bars.

Separating and Cleaning. Excessive speed of the straw rack will tend to throw threshed grain out the rear of the machine, while too slow speed gives poor separation. Adjustments for the chaffer, sieves, and cleaning fan are similar to those described for threshers.

JOB 19

CARE AND ADJUSTMENT OF CHAINS

Various types of metal chain are used to transmit power in farm implements. Chain is especially desirable when the distance between the center of the sprockets is not rigidly fixed but may vary slightly.

The common types are illustrated in Fig. 241. Open-joint link chains are used for comparatively slow-moving sprockets. Roller chains are made of hardened steel and are used for

heavier loads and greater speeds. Silent chains, having teeth on one side to engage the gear teeth, are used for driving the timing gears of engines.

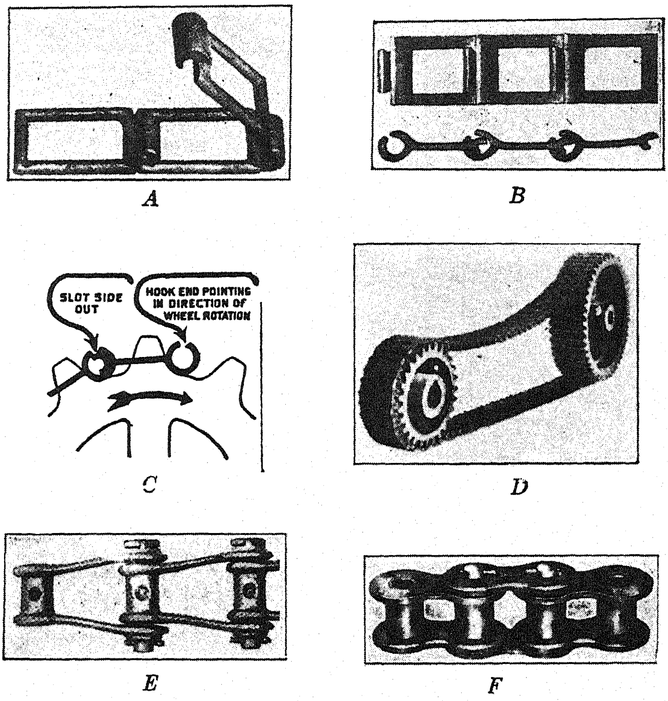


FIG. 241. Common types of chains. *A*—Malleable-iron link belt or chain. *B*—Steel chain. *C*—Showing how steel chain should be placed on sprocket. *D*—Silent chain. *E*—Pintle chain. *F*—Roller chain.

1. Check the alignment of sprockets as indicated. Misalignment causes rapid wear of both the sprockets and chains. Replace sprockets that have worn until the teeth are hook-shaped. (See Fig. 242.)

2. Assemble open-joint link chains on the sprockets as indicated; the open side of the hook should be out and the hook end should lead. (See Fig. 241.)

3. To disconnect an open-joint chain, bend the chain as shown and strike the side of the link to drive it out. (See Fig. 241.) The hook opening, of open-joint steel chain, is made slightly smaller than the side bar; so a light blow of the hammer is necessary to uncouple the links. Malleable, open-joint chain is uncoupled in the same manner.

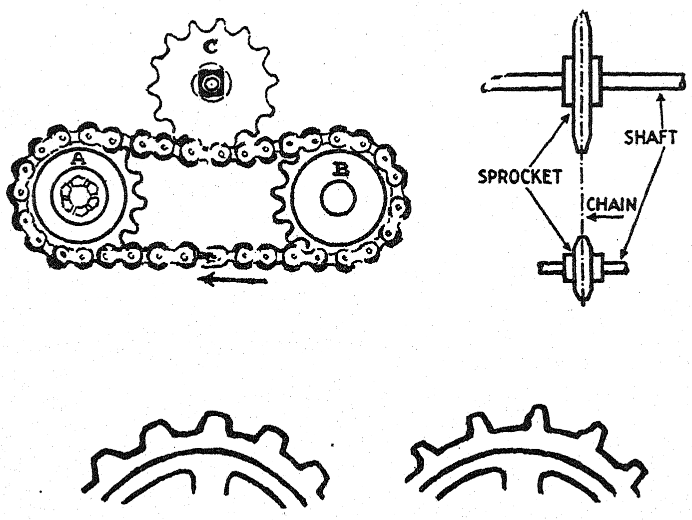


Fig. 242. Position of chain tightener. Alignment of sprockets. New and worn sprocket teeth.

4. Chains should not be adjusted too tight, but should run with a slight amount of slack. When chain tighteners (adjusters) are used, they should support the slack side of the chain. (See Fig. 242, where *A* is the driving, *B* is the driven sprocket and *C* is the tightener.)

5. Remove chains frequently and clean them by dipping in kerosene. When clean and dry, dip them in oil or leave them immersed in oil until the oil penetrates well into the joints of the links.

CHAPTER X

POTATO PLANTERS AND DIGGERS

There are two principal types of potato planters: the automatic-feed illustrated in Fig. 243, and the assisted-feed type in Fig. 246. The former is the more widely used. It has a mechanical picking device which drops the seed at regular intervals. In the assisted-feed machine, the work of spacing the distance between seeds is not entirely mechanical. One man frequently has to place the seed in the seed-carrier pockets by hand. This work requires his entire attention; therefore a second man is needed to drive the machine. It is claimed that the two-man planter is more accurate than the one-man machine, and this type of machine is used by many growers of seed potatoes.

The potato planter should open a furrow of proper depth for the seed, drop the seed to the bottom of this furrow at regular intervals, and cover the seed well. Provision must also be made for sowing fertilizer with the seed.

To accomplish these things under the many different conditions that exist, certain adjustments are necessary. It must be possible to regulate the depth of planting and the distance between seeds must be variable to suit different field conditions; the distance between rows must be variable; a marker must be provided in order that the operator may plant in straight rows; and a fertilizer attachment must be combined with the planter.

Sizes. Planters are built in both one-row, two-row, three-row, and four-row sizes. Multiple-row machines accomplish the work rapidly and also facilitate the use of multiple-row cultivators. The use of two-row planters, two-row cultivators,

and even two-row diggers is increasing. At the present time two-row, tractor-operated units are the most popular size in potato-growing districts.

Potato planters are comparatively heavy. The total weight of a two-row planter with seed, fertilizer, and the weight of the operator may reach 3000 pounds. Hence all types are trailed; no tractor-mounted types have been developed.

Construction and Principal Parts

Main Frame (Fig. 243). The main frame is usually made of angle steel, channel steel, or heavy flat stock. It forms a support or point of attachment for all the other parts of the planter and must maintain all parts in correct alignment. Because of the great weight of a fully loaded planter, the strength and rigidity of the frame is of primary importance.

Main Axle (Fig. 243). The main axle is a straight steel shaft about 2 inches in diameter. On single-row planters, it is a drive axle and transmits power from the main wheels to all working parts of the planter. It is bracketed to the main frame and is provided with bearings at either end. Some multiple-row planters have a one-piece axle, but other designs use a two-piece axle.

Main Wheels. Power is taken from the main wheels to drive the working parts of the seeding and fertilizer mechanism. Because of the weight of multiple-row planters, the wheels must be strongly made in order to serve their dual purpose of transporting and driving. Steel wheels, 36 inches in diameter with concave steel rims 6 inches wide, are furnished for two-row planters. Pneumatic tires, 7.50 by 28 inches, are available for the two-row sizes. High wheels permit lifting the furrow openers high from the ground for transport, which is particularly advantageous in stony fields. Skid rings may be applied to the wheels to prevent side-slipping on hills. Wheel scrapers, also, are available.

On the four-row planters, tires 9.00 by 24 inches are used.

Transmission of Power. Ratchet and pawls are employed to transmit power from the main wheels to the one-piece axle. Power from the main wheels is transmitted to the seeding mechanism and the fertilizer feed. The rotating rate that these two members have must be in definite relation to the rate of

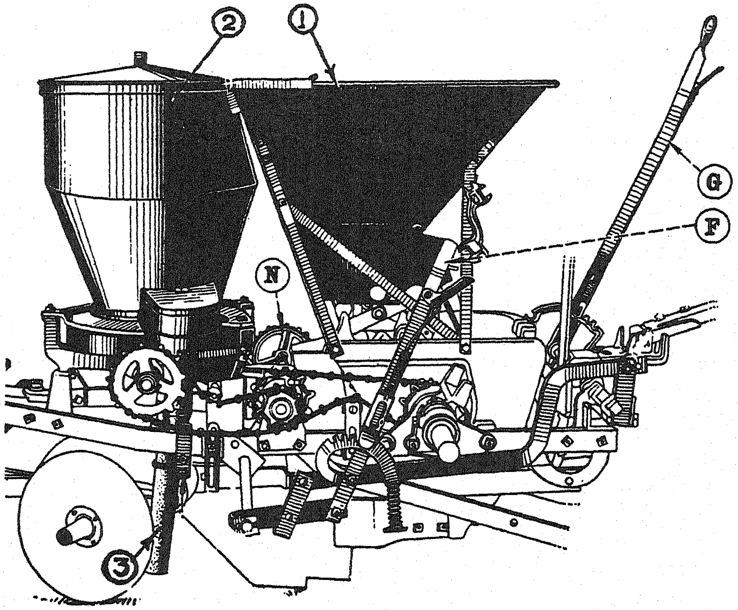


FIG. 243. One-row, automatic potato planter. 1—Seed hopper. 2—Fertilizer hopper. 3—Fertilizer tube. *F*—Adjusting lever for furrow opener. *G*—Lifting lever. *N*—Sprocket and chain for picker drive.

travel, in order that the distance between seed pieces and the amount of fertilizer may be appropriate. The means of transmitting power for these purposes is similar in the various types.

In the planter shown in Fig. 243, the pawl holder is pinned to the axle, and the ratchet is part of the hub of the wheel. The action of the pawls and ratchet has been described in the chapters on drills and mowers.

On two-row planters, two short axles are used and the ratchet and pawls are not required. The axles do not revolve but are fixed in position. A revolving sleeve is placed over each axle, and on the sleeve is mounted the clutch and main drive sprocket.

The clutch consists of two parts—a driving half and a driven half or a clutch sprocket which is free on the axle. Each of these parts carries notches which lock together when the clutch is engaged.

The clutch is operated automatically by the action of a control lever. This lever (Fig. 243*G*) lowers the furrow openers and covering attachment and determines the depth of planting. Raising the furrow openers from the ground disengages the clutch. Forward motion of the planter drives the main sprocket, but when the planter is backed up the notches of the two clutch halves slip rather than drive. Thus it is a "one-way" clutch. If ratchet and pawls are used, slippage occurs in the ratchet when the planter is reversed.

A chain from the main-drive sprocket carries the power forward to a countershaft. Two chains with their sprockets convey power from the countershaft; one carries forward to the fertilizer-feed drive shaft, and the other (*N*) carries power back to the seed pickers (Fig. 244). A slip clutch (Fig. 258) is used on the countershaft, the two halves of which are held in engagement by the spring pressure. Should a stone wedge in the seed hopper, slippage will occur before breakage of other parts.

Seeding Devices. 1. *Picker-arm Type.* The potato seed is carried in the main hopper and flows down to a lower hopper or magazine by gravity. The size of the opening between the upper and lower hoppers is usually adjustable. A liberal supply of seed must be present in the lower magazine. An agitator wheel or similar device is used between the upper and lower hoppers to insure an even flow of seed. To prevent too great an accumulation of seed in the lower hopper, an auto-

matic shut-off is used which stops the flow when necessary and thus avoids waste of seed.

Several picker arms (Fig. 244) are bolted to a rotating center (spider) which is chain-driven from the countershaft. In the construction illustrated, the main axle serves as a bearing for the picker spider. The spider is mounted on the main axle but not directly connected to it. As the picker arms re-

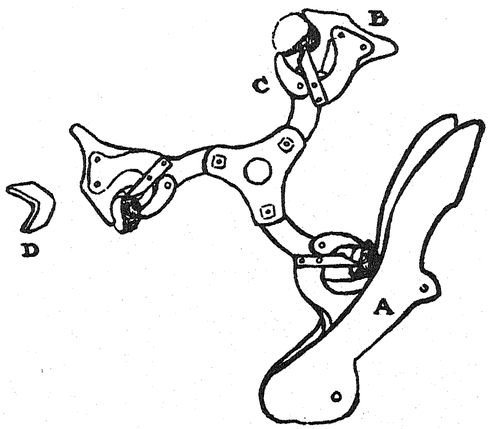


FIG. 244. Picker-arm seeding device. *A*—Concave. *B*—Picker head. *C*—Thumb piece. *D*—Stripper.

volve through the lower hopper or magazine, each picker spear, aided by its thumb piece, picks up a piece of seed and carries it forward to the rear of the furrow opener. At this point, a stripper strikes the stripper plate and pushes the seed off the spear. Then it drops to the bottom of the furrow. When the spears enter the seed, they press it against the concaves. These long, cup-shaped parts, mounted at the rear of the lower hopper, are held in place by adjustable spring pressure. When the seed is pressed against them, they retract slightly, and thereby force the seed onto the spears with a gentle pressure, thus preventing splitting or mashing of the seed piece.

The distance between seeds may be varied by changing the size of the sprockets which drive the picker shaft. Planters may be furnished with the necessary sprockets to plant seed at distances varying between 6 and 20 inches.

2. *Picker-wheel Type* (Fig. 245). The wheel is centered in the lower hopper. It carries eight to twelve picker arms, each

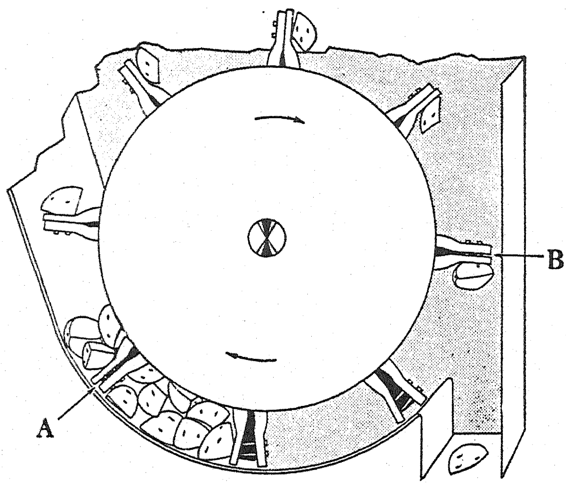


FIG. 245. Picker wheel. *A*—Picks spearing seed. *B*—Releasing seed.

of which is provided with two points, or picks. Two lengths of picks are furnished—long picks for whole seed or large-cut seed, short picks for smaller seed pieces.

Picker arms are arranged in a staggered position on the wheel. This prevents one arm from trailing the preceding one. The picks are withdrawn by the cam action, when the arms approach the bottom quarter of their revolution. This withdrawal strips the seed piece from the points, and the seed then falls directly to the seed furrow. The picker arm then enters the seed supply with the picks still in the withdrawn position. Just as the picks begin the upward quarter of their revolution, cam action and spring pressure cause them to "strike" forward and spear a seed piece.

The picks may be located at various positions in the end of the picker arm, as shown in Fig. 245, depending upon the size of seed pieces used. Picks should be kept sharp and should be replaced frequently.

3. *Assisted-feed Type* (Fig. 246). This construction is used in the two-man planter. It consists of two feed wheels. One,

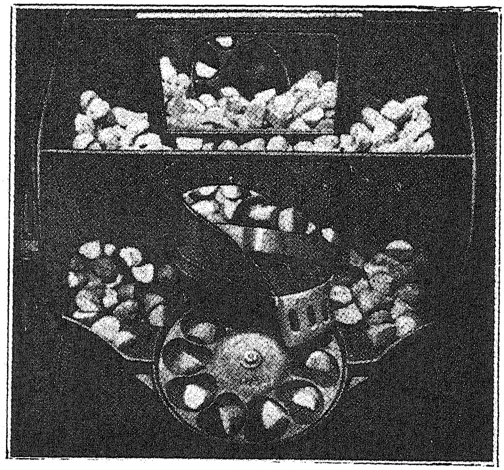


FIG. 246. Assisted-feed planter.

called the *elevator wheel*, is placed in an inclined position. It carries single seed pieces from the seed hopper to the second or *pocket feed wheel*. The elevator wheel is timed to fill each pocket in the horizontal pocket feed wheel. Usually it does so entirely automatically. The pocket feed wheel revolves slowly and carries each seed piece to the open planting tube where the seed drops into the seed furrow.

The rate of seeding (spacing) is determined by the number of pockets in the wheel or by the speed at which the wheel revolves. Different sprockets are available for driving this wheel, giving a planting position of 7 to 23 inches.

Because of the slow speed of the pocket feed wheel the operator, sitting behind it, may inspect each pocket, filling

empty pockets, removing double or defective seed pieces. For this purpose, he keeps a reserve of seed in the reservoirs at the center and sides of the feed wheel.

Hoppers. Separate hoppers are provided for seed and fertilizer. They should be large and strongly built, for each must carry a heavy load. Seed hoppers hold about 2 bushels, fertilizer hoppers about 300 pounds. The amount of seed and the quantity per acre vary greatly, but some growers use as much as 20 bushels of seed and 3000 pounds of fertilizer per acre. Because of these conditions, the weight of a fully loaded planter is such that strong, rigid construction is essential. A typical two-row tractor-planter weighs 1600 to 1800 pounds. To this is added at least 120 pounds of seed for each hopper, 300 pounds of fertilizer for each hopper, and the weight of the operator. On larger fields it is often necessary to carry extra bags of seed and fertilizer. Considering all these factors, the total weight reaches 3000 or more pounds.

Fertilizer Attachment. A separate furrow opener is usually provided for the fertilizer attachment. Tubes extending down from the fertilizer hopper carry the fertilizer to the ground. The placement of these tubes is such that the fertilizer is mixed with the soil before it comes into contact with the seed. The front hopper carries the fertilizer.

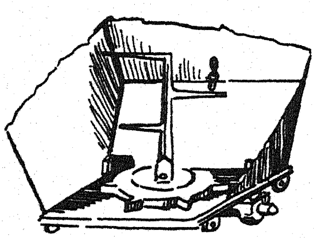


FIG. 247. Fertilizer-feeding device.

The fertilizer-feeding device (Fig. 247) is provided with an agitator to prevent clogging and to give an even flow. The rate of feed is regulated by changing the driving sprockets or by varying the size of the outlet from the hopper. Most planters are designed to sow any desired quantity of fertilizer per acre—300 to 3500 pounds.

Exact placement of the fertilizer with relation to the seed

piece is essential. There should be no contact between them. The usual custom is to place the fertilizer in 2-inch bands at each side of the seed row on the same level with the seed. This is accomplished as shown in the four-view sequence in Fig. 248. First, the fertilizer-furrow openers (*A*) open two furrows for the fertilizer, leaving a level strip between them. The fertilizer drops through the spouts (*B*) into the prepared furrows. Then the seed-furrow (*C*) opener splits the level strip and the seed falls to the center of the seed furrow. Finally the disk coverers throw sufficient soil toward the center to cover both seed and fertilizer. This band method of placement is shown by the diagram in Fig. 249. No single method of fertilizer placement will be fully satisfactory for all conditions. Modern planters are designed to meet these varying demands and so place the fertilizer as indicated in Fig. 249.

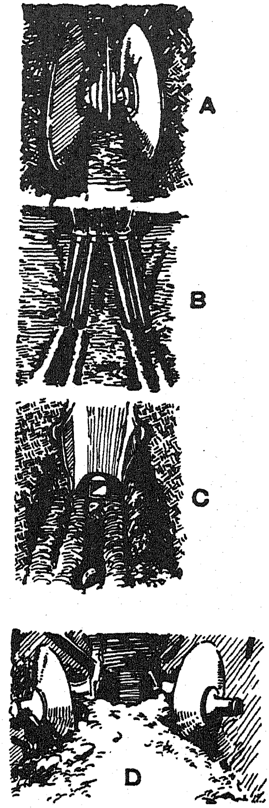


FIG. 248. Action of furrow openers, fertilizer tubes, and covering disks.

Marker. Several types of markers are used, but all have the same function. For one-row planters, the marker should be set so that the horizontal distance from the seed-furrow opener to the line made by the marker is the same as the distance desired between the rows. For two-row planters, the distance should be twice the distance desired between rows.

Hitch. On horse-drawn planters, a long wooden pole is attached to the forward end of the main frame. Two-horse eveners are used with the single-row potato planter.

Tongue trucks are not commonly used, but a caster wheel may be obtained. This relieves the horses of neck weight and supports the front of the planter.

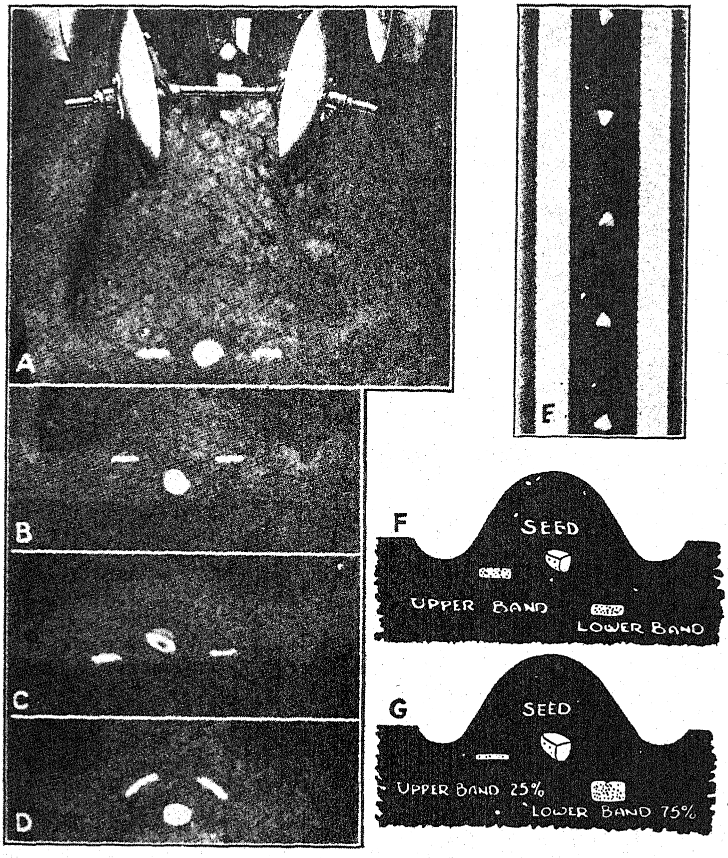


FIG. 249. Various placements of fertilizer.

Tractor-drawn planters are furnished with stub pole, and provision is made for vertical adjustment in order that the hoppers may be kept level when in operation.

JOB 20

TO REPAIR A POTATO PLANTER

1. Get the owner's or operator's report on the condition of the machine; field troubles; worn, broken, or missing parts; faulty adjustments; name of the manufacturer, and year of purchase. Try to secure the repair catalog and the instruction book furnished with the planter.

2. Test and inspect all parts. Jack up the planter securely, with both drive wheels clear of the floor. Lower the furrow openers and, with clutches engaged, turn one drive wheel and test the action of all moving parts, both in the seeding and fertilizing mechanisms.

3. List all repair operations needed.

4. Order necessary repair parts.

5. Clean seed and fertilizer hoppers. The fertilizer drive parts and hopper may have to be disassembled for thorough cleaning. After cleaning they should be painted to prevent rust from accumulating. The acids in the fertilizer corrode the metal and pit it deeply unless it is well protected by paint.

6. Repair furrow openers and coverers. The bearings of the disk-furrow openers and coverers should be disassembled, cleaned, and replaced if necessary. The seed-furrow opener (shoe type) should be checked for alignment, and the bolts connecting it replaced if worn. It is important that this be kept in correct alignment, especially on two-row planters.

7. Repair seed-picking mechanism. Sharpen or replace the picker spears. See that the thumb pieces and picker heads work freely. Oil them thoroughly.

On picker-wheel planters, the action of the arms should be carefully tested. Spring action causes the spears to strike forward into the seed piece. If the springs are weak or if the parts are rusted this action will be impaired.

8. Test and repair the concaves. Action of the concaves requires correct spring pressure and free movement on their pivots. Keep these pivot shafts clean and well lubricated.

9. Repair and adjust chains. Remove the chains, wash them in kerosene, and examine for wear. Then, immerse the chains in oil and adjust their tension. (See p. 338.)

10. Lubricate all bearings.

11. Paint all parts that are likely to rust. The seed and fertilizer hoppers in some planters are made of sheet iron. These should be well protected. Oil or grease all polished-steel surfaces.

Operating a Potato Planter

Adjust the Picker Spears. The picker arms in some planters provide several places where the picker points may be attached. For small seed the point should be set in the hole nearest the end of the picker arm; for large seed it should be set in the hole farthest from the end of the picker arm.

Adjust the Concaves. At the rear of the planter in the bottom of the picker pit, flexible troughs are placed. These are the concaves (Fig. 244). The picker points or the spears pick up the potatoes from the groove or trough on the inner face of the concaves. Two of these concaves are usually provided, one for each set of picker arms. They are flexible to accommodate themselves to the various sizes of seed. Their tension is adjustable by means of a spring, and they should be set to hold the seed firmly against the pickers. The concaves should be set farther back from the the picker shaft when large seed is planted.

Adjust the Hitch. The height of the pole should be such that the planter frame and hoppers will be level when the machine is in operation. This adjustment is made by the neckyoke straps if horses are used. With tractors, adjustment is usually provided at the drawbar of the tractor or vertical clevis on the planter.

Fill the Seed and Fertilizer Hoppers. Because the quantity of seed and fertilizer per acre is usually large, a suitable supply of both should be placed at the ends of the fields.

Some growers carry an extra supply on the planter, in addition to that in the hoppers, so that they will not run out of either seed or fertilizer while in the field. Extensions to increase hopper capacity are sometimes used for long rows.

Select Drive Sprocket. Select the proper sprocket to give the desired distance between seeds. This distance is varied by changing the feed sprockets. Nine, 11, 13, 15, and 17 inches are all standard distances. Planters are usually furnished with two sprockets, one for 13 inches and one 15 inches. Sprockets for other distances are available. With some makes, the number of teeth on the sprocket indicates the inches of spacing; an eleven-tooth sprocket will space the seeds 11 inches.

Regulate Fertilizer Feed. The fertilizer-feed settings are not usually marked on the potato planter as they are on the grain drill; consequently, it is difficult to get the desired rate of flow the first time. As the operator becomes familiar with his planter, however, and has an opportunity to check the amount of fertilizer used against the acreage covered, this adjustment will be more accurately controlled.

Adjust to sow the desired quantity per acre, as described on p. 348. The fertilizer-delivery spouts or tubes should be set to spread the fertilizer along the sides of the seed furrow. Fertilizer should not be allowed to touch the potato seed. The fertilizer-feed wheels in some planters are equipped with "cut-off pins," or break pins. If an obstruction enters or parts become jammed, these pins shear off and so prevent more serious damage. Breakage is probable if fertilizer is permitted to remain long in the hopper, for it hardens or cements quickly when exposed to air.

Field Adjustments

Marker. The adjustment of the marker described on p. 349 determines the distance between rows. Thirty-four inches between rows is a standard in potato-growing regions, although row widths of 32 inches and 36 inches are also used.

Depth of Planting. The depth is controlled by the raising lever. Two-row planters may have a separate lever for each furrow opener. When the desired depth setting is found, the operator should endeavor to secure uniform depth throughout the field.

On some planters an adjustment affecting the depth is also possible at the furrow openers.

Covering Disks. The angle of the disks and the downward pressure on them are adjustable. Increasing the angle makes a higher ridge and throws the dirt in farther. Practice in covering varies in different regions. Some growers cover the seed lightly; others throw a high ridge over it. These disks not only cover the seed but also the fertilizer, which they mix with the soil.

Flow of Seed from Hopper. The agitator in the bottom of the seed hopper loosens the seed and causes it to flow down to the picker arms, or wheel. Some planters have an adjustment controlling the movement of the agitator. This should be set so that an ample supply of seed is delivered to the picker pit. In some planters, a feed gate is located between the seed hopper and the picket pit (also called magazine). This gate should be kept open wide enough to permit plenty of seed to enter the picker pit. If closed too much, the gate may become clogged, or "bridged over," and cut off the flow of seed to the magazine. Some models provide automatic control of the flow of seed from upper to lower hopper.

Depth of Fertilizer Placement. The fertilizer will fall to the bottom of the trenches which were prepared for it by the fertilizer-furrow openers. These may be adjusted to control the width as well as the depth of the bands of fertilizer.

Potato Diggers

Potato diggers, like all other farm implements, had passed through many stages of development before the present, standard type was designed. Various shapes of blades have been

used for raising the potatoes out of the ground. Many devices have been tried for separating the potatoes from the accompanying mass of earth and vines.

The function of the modern digger is to dig the potatoes from the ground, separate them thoroughly from the vines and soil, and drop them in rows or piles so that they may be easily

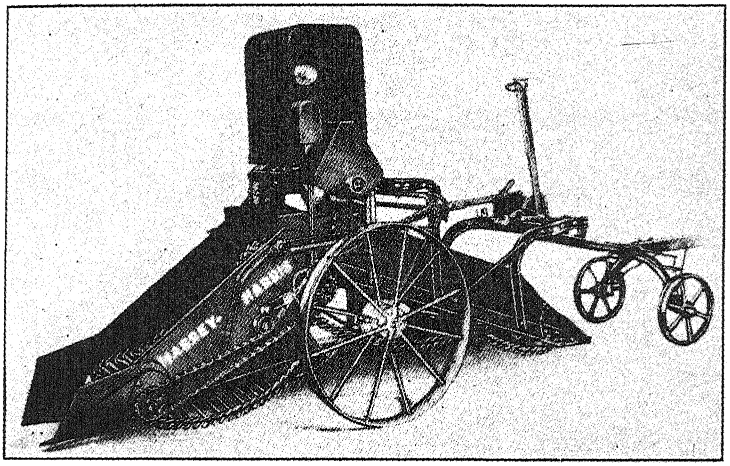


Fig. 250. Standard type of elevator digger with engine.

gathered. To some extent, potato diggers have been equipped with picking attachments. By means of them, the potatoes are deposited in piles or crates so that the work of gathering is much easier. Such attachments, however, have been only partially successful and are not in general use.

Types and Sizes. The elevator digger illustrated in Fig. 250 has come to be the standard. The size is determined by the width and length of the elevator (see arrows, Fig. 253). The elevators of the smaller machines are usually 20 inches in width and 5 to 6 feet long. The larger machines, designed to be drawn by four horses or by a tractor, have 24- or 26-inch elevators, 6 or 7 feet long. A machine of this size has a heavy

draft and is a full load for four horses. To lessen this load and to prevent slippage where traction is difficult, a separate engine is mounted on the digger to drive all its mechanism. Then the digger can be drawn by two horses or a light tractor. A 6- or 8-horsepower engine is desirable.

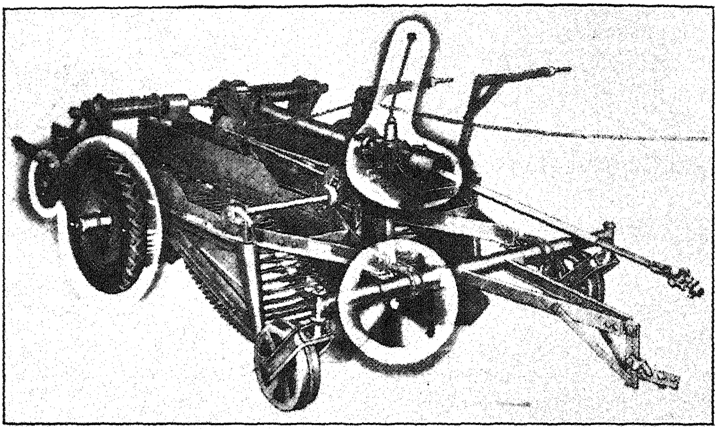


FIG. 251. Two-row, power-take-off tractor digger.

The standard machine digs one row at a time. Two-row tractor diggers, operated by a power take-off from the tractor, are now in common use in the principal potato-growing regions.

CONSTRUCTION AND PRINCIPAL PARTS

Standard Ground-driven Type

Main Frame (Fig. 252*b*). The main frame is made of two pieces of angle iron, one at each side of the digger. These are cross-tied with a short angle iron. The main frame supports the sideboard of the elevator and carries the brackets to which the shovel is attached. Two brackets are also carried at the rear of the main frame. The main axle is held in these brackets, which are located toward the rear of the elevator. The digger beam (*e*) is connected to the front end of the main

frame. Various sprockets for operating the elevator chain links are also connected to the main frame.

Main Wheels. Both main wheels are drive wheels. They furnish the power for all the other moving parts. Large lugs are used to secure good traction. The steel ring (Fig. 252) is removed when the digger is at work. Steel wheels are used, varying in diameter on different diggers from 32 to 36 inches. The main axle is a fixed or "dead" axle, and the wheels revolve on it.

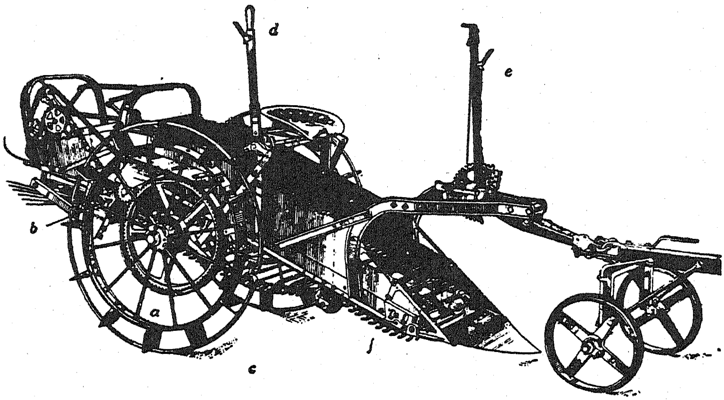


FIG. 252. Standard type of elevator digger.

Ratchet and Pawls. Power is transmitted from the wheels to the main drive gear. Both chain-driven and gear-driven diggers are in common use. Figure 252 shows the main wheel and the gear of a gear-driven digger. Small latches are placed in the main wheels of some diggers to engage and disengage the pawls. When the digger is being transported to the field, the pawls are disengaged. This means of engaging the pawls serves as a clutch. In some diggers the action of the shaker lever (Fig. 252*d*) or the shovel-lifting lever engages and disengages the pawls.

Main Drive Gear. One main drive gear is mounted on the main axle at each side of the digger. (Drive sprockets of

similar size are used on chain-driven diggers.) These gears act as pawl holders and transmit the power to the main drive pinion.

Main Drive Pinion. A main drive pinion is mounted on each end of the main drive shaft. This pinion meshes with the main drive gear and receives the power from it.

Main Drive Shaft. The main drive shaft extends across the end of the digger underneath the rear of the elevator. All of the working parts of the digger are driven from this shaft. Figure 253 shows the location of the main drive shaft and the sprockets (*b* and *c*) which are keyed to it and drive the elevator chain. These are keyed to the shaft so that they revolve just inside the elevator sides. The shaker-drive sprocket (*d*) and the vine-turner-drive sprocket (*e*) are also keyed to the main drive shaft. In brief, the main drive shaft has three distinct functions:

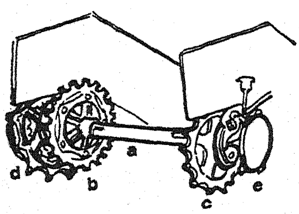


FIG. 253. Main drive shaft and sprockets.

(*a*) It drives the elevator.
(*b*) It drives the vine turner (Fig. 254*b*).
(*c*) It drives the shaker (Fig. 254*c*).

It is carried in brackets mounted under the main frame and is provided with renewable bearings.

Elevator (Fig. 255). The elevators are made up of links of rod in the form of a chain. One-half of the elevator-link rods are bent slightly upward and one-half are bent downward, the raised links alternating with the lowered ones. This forms pockets to carry the potatoes up the elevator and aids in separating them from the soil and vines.

The elevator is driven by the two large sprockets on the main drive shaft. Each side of the elevator is provided with agitating sprockets, as shown in Fig. 256*f* and *g*. As these

sprockets revolve, they "agitate" or shake the elevator links, which aids in separating the potatoes from the vines. The underside of the elevator chain is supported by rollers which take up the slack in the elevator. The bearings of all of the sprockets and rollers are renewable and must be frequently replaced. It is difficult to lubricate them successfully. They

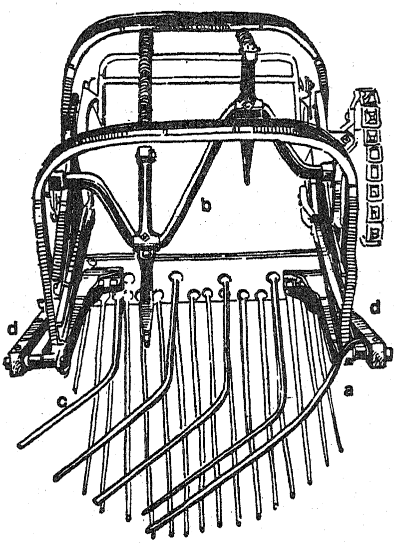


FIG. 254. Vine turner and shaker.

are covered with soil when the digger is in operation. Dirt and sand work into the bearing and cause rapid wear.

The elevator chain should be kept as tight as it can be hooked up by hand. If the chain becomes too slack, it may climb on the driving sprockets or else vegetation may wedge under it. Chain links must be removed when necessary to tighten the elevator chain.

Vine Turner (Fig. 254*b*). The vine turner, with its crank and forks, separates vines, grass, and weeds from the potatoes and soil. The revolving forks, with the aid of the vine-turner

rods (*c*), free the vines and turn them to one side. This piles the vines and trash at the side of the row of potatoes. The potatoes drop to the ground at the center of the rear of the digger.

Shaker (Fig. 254*a*). The potatoes pass up the elevator and are delivered to the vine-turner rods. Here the action of the forks frees the vines. The potatoes, and the soil that is mixed with them, drop through the wide-spread vine-turner bars (*c*) onto the closely spaced bars of the shaker (*a*). The shaker is

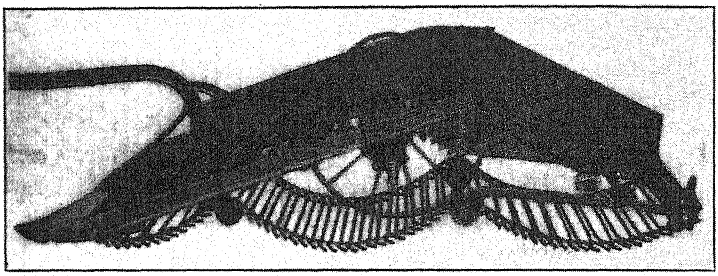


FIG. 255. Continuous elevator.

mounted at the rear of the digger. It oscillates back and forth, sifting the soil through the bars and dropping the potatoes off the end of the bars.

The shaker is suspended by hangers at the rear of the frame. It is given an oscillating motion by the pitmans (*d*). One pitman is used on each side of the shaker. Pitmans are attached to crank wheels on the shaker crank shaft. This shaft is driven by a chain from the main drive shaft.

The shaker hangers and the pitmans are subject to rapid wear and should be well lubricated. They are always provided with renewable bearings which need to be replaced frequently. The angle or downward pitch of the shaker is controlled by the lever (Fig. 252*d*).

Shovel (Fig. 256*d*). The shovel of the digger is made of highly tempered steel. It must be hard enough to scour well

under many different soil conditions. It is bolted to the shovel brackets at the lower ends of the elevator sides.

The shovel is lowered into the working position by means of the shovel-lifting lever (Fig. 252*e*). It must penetrate deeply enough to get under all of the potatoes. If it is set more deeply than necessary, the draft is greatly increased. Regula-

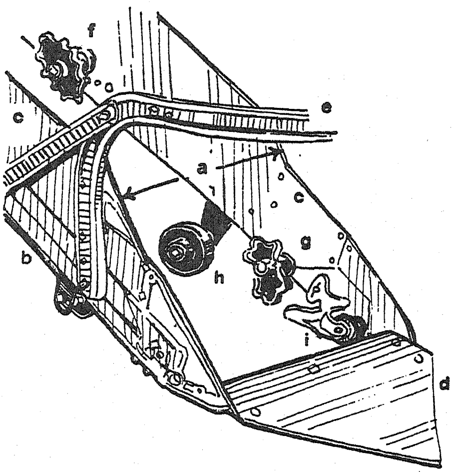


FIG. 256. Detail of main frame, shovel, sideboards, and beam.

tion of the depth is controlled by the shovel-lifting lever which is attached to and operates the shovel-lifting beam. Special shovels are available to meet difficult field conditions (Fig. 260).

Extension Elevator or Continuous Elevator. On fields where the surface growth and vines are not heavy, the shaker and vine turner are frequently replaced by the extension elevator or the continuous elevator. Bruising of the potatoes is lessened by the use of either, particularly with the extension, as the potatoes are handled more gently. Clean fields, free of grass and weeds, are essential to the successful use of the extension elevator.

Tongue Truck. Potato diggers are regularly equipped with tongue trucks. The truck wheels support the weight of the front of the digger and make possible the convenient location and simple design of the lifting lever. The wheels are designed

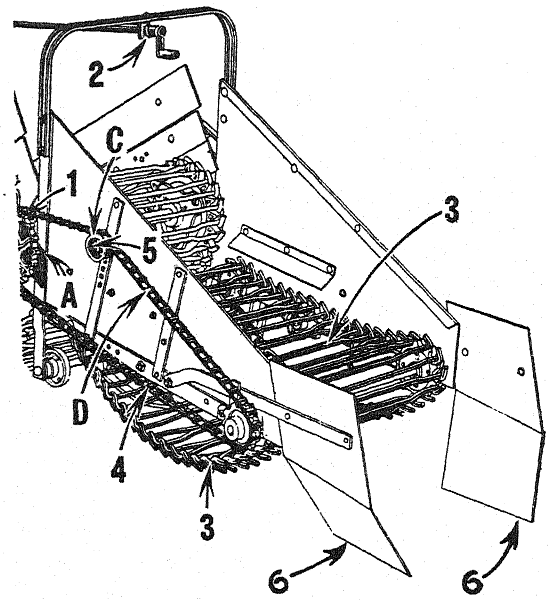


FIG. 257. Extension elevator (3). Deflectors (6). Extension elevator adjuster (2). Drive chain (*D*). Chain adjuster (*C*).

for the short turning usually necessary at the ends of the rows.

Transmission of Power (Tractor-driven Types). In recent models the extension shaft (Fig. 251) transmits power through an automobile transmission, which has the usual three forward speeds and a reverse speed. The elevating speed may be quickly changed to suit field conditions, and the reverse is used to dislodge stones or loosen a clogged elevator. The drive is extended to the rear of the machine, where a bevel pinion and gear transmit the power to the cross shaft. Power is trans-

mitted from the cross shaft through slip clutches (Fig. 258) and from a chain to the elevator-driving sprockets at each side of the digger. The pneumatic-tired wheels, used only for transport, reduce the draft of the machine materially and also reduce bruising.

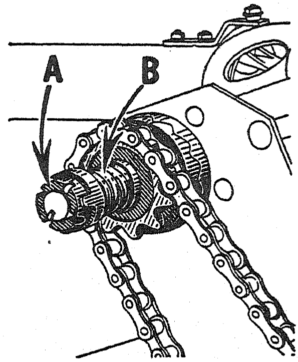


FIG. 258. Slip clutch. *A*—Tension adjustment. *B*—Clutch spring.

Power Lift. Both tractor-driven and ground-driven power lifts are used with tractor diggers. Lifting is accomplished by raising the shovel toward the digger beam, the center of the digger pivoting on the main axle. The lift is operated by a rope from the tractor seat and, as other controls are accessible from the seat, the two-row tractor digger may be operated by one man.

SPECIAL EQUIPMENT

Stone Trap (Fig. 259). The stone trap is a useful addition to the digger for use in stony fields. It is mounted between

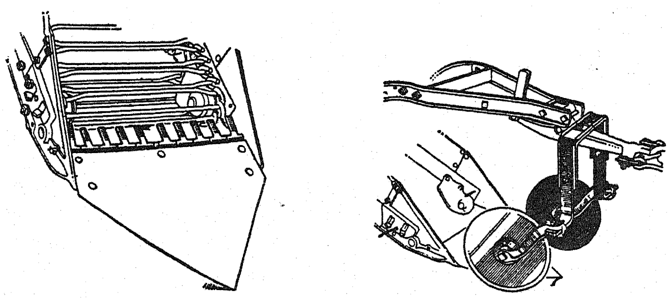


FIG. 259. *Left*—Stone trap. *Right*—Rolling coulters.

the lower end of the elevator and the shovel. A series of iron fingers permits stones from beneath the shovel to pass through, instead of lodging between, the links and the shovel.

Rolling Coulters (Fig. 259). Rolling coulters may be used to good advantage on fields that have a heavy growth of vines, grass, weeds, etc. Under such conditions, trouble is caused by the heavy surface growth lodging on the sides of the elevator and wedging under the beam. A rolling coulter is mounted at each side of the shovel. If kept sharp, it cuts through the surface trash so that only the strip in front of the shovel is elevated.

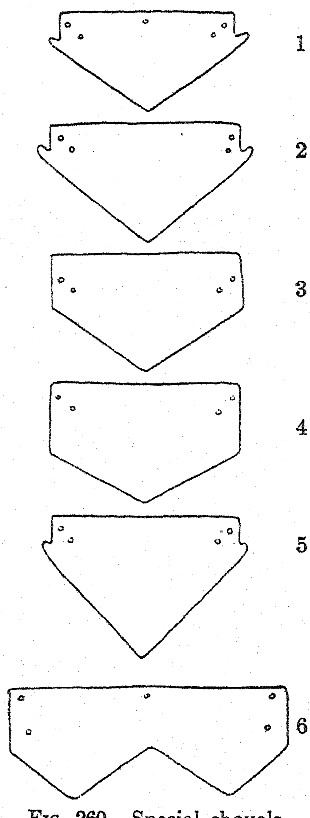


Fig. 260.—Special shovels.

Center Cleaning Device (Fig. 251). Where vines and trash are heavy and green the center cleaning device is helpful on two-row diggers. It cuts through such surface material and lessens the amount drawn up the elevator.

Special Shovels (Fig. 260). Several shapes of shovels are available for various field conditions. The short 12-inch shovel (1) is recommended where potatoes are ridged or hilled high because it lessens the amount of soil to be elevated and scours well under difficult conditions.

The 14-inch shovel (2) is adapted to average conditions because it extends well back toward the elevator.

The shapes shown at (3 and 4) with slight angle cuts grass and roots well.

The 17-inch shovel (5) is furnished where potatoes are deep

or where there are sandy, gritty soils which cause rapid shovel wear.

The double-pointed shovel (6) forces the slice cut toward the center of the shovel. It prevents trash and roots from hanging over the sides and from rolling potatoes aside before they reach the elevator.

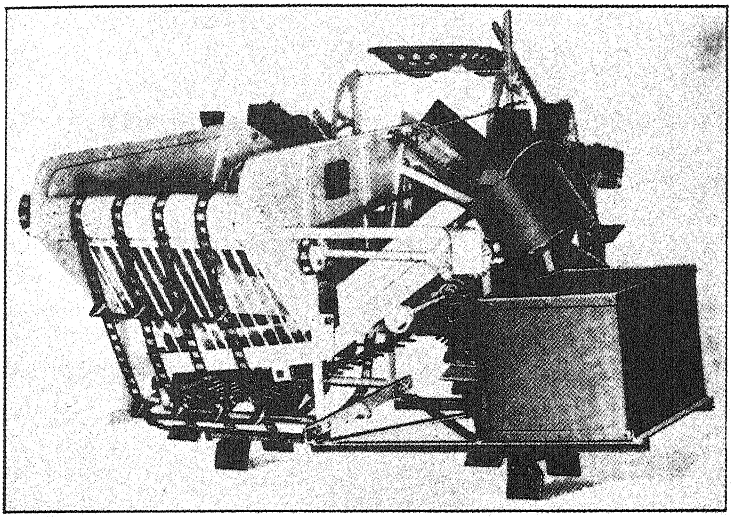


FIG. 261. Picking attachment.

Earth Spreader. This attachment deflects the soil to either side and causes the potatoes to fall in the shallow trench cut by the shovel, thus facilitating the labor of picking up. Picking up the potatoes is still handwork in most regions, and is the most costly operation of the potato grower.

Rod Deflectors. They may be used at the rear of the digger instead of the solid type. Under many conditions they give cleaner separation.

Picking Attachments (Fig. 261). Many successful attempts have been made to develop satisfactory potato pickers. Some of the designer's problems are the great length such units

may require and the problem of separating stones, clods, vines, and soil from potatoes. In heavy yields the picker must work very rapidly, yet must not bruise the green potatoes. In some regions, picking attachments, such as the type illustrated, are used to a limited extent. They give best results on clean fields of light soil that is free from stones and has light vines and little trash.

JOB 21

TO REPAIR A POTATO DIGGER

1. Get owner's or operator's report on the condition of the machine, worn or missing parts and faulty adjustments, field troubles, etc. Secure the appropriate repair catalog and the manufacturer's instruction book.

2. Test and inspect all parts. Test the action of all parts by drawing the machine or by jacking it up and driving all parts. Test the bearings of all rollers, sprockets, pitmans, shafts, etc.

3. Make a list of repair operations needed.

4. Order repair parts.

5. Sharpen the shovel. Remove and sharpen the shovel. This may be ground on the emery wheel or grindstone. Grind it on the same side that was originally ground. (Some manufacturers grind the upper and some the lower side.) Try to preserve the original bevel.

6. *Elevators.* Unhook the elevator rod chain and remove it from the digger. Examine it carefully for worn or broken rods and replace any such. Straighten any that are bent.

Disassemble all the rollers and agitator sprockets (Fig. 256). Wash all these parts clean in kerosene and test the bearings for wear. Replace the bearings if necessary.

7. *Main Wheels and Pawls.* Examine the pawls and pawl spring in the main wheels. Replace worn pawls and springs. Clean out oil tubes that lead to the main-wheel bearings, and wash the bearings thoroughly with kerosene. Tighten main wheel lugs.

8. *Main-drive Shaft.* Test the bearings of the main-drive shaft. Some machines have plain bearings and others have roller bearings at this point. Clean out the grease tubes and bearings thoroughly. Put in new bearings if required.

9. *Chains and Sprockets.* Remove all chains and examine them for wear. Clean and lubricate the chains. (See p. 338.) Examine all sprockets for wear. See that the chains are put on properly and the sprockets in good alignment.

10. *Shaker and Pitmans.* Test the shaker-hanger bearings and the pitman bearings (Fig. 254). These wear rapidly and need replacement nearly every season. In some machines the pitman bearings are adjustable in order that the wear may be taken up.

11. *Vine Turner.* Tighten the vine-turner forks (Fig. 254) so that there is no looseness between them and the shaft. To take up wear at this point, it is often necessary to remove the fork and to file the material from one-half of it. This allows the halves to draw more tightly together. Straighten any rods that may be bent in the vine turner or shaker.

12. Clean and lubricate gear housings. Drain the lubricant from the auto transmission (Fig. 251) and the bevel-gear housing. Then flush them clean and refill to the proper level with the correct grade of lubricant.

13. Lubricate other parts. Test their action when they are completely reassembled.

14. Paint as required. Grease the shovel.

Operating a Potato Digger

1. The machine should first be well lubricated. Then, running it idle for a few moments will test it. Be sure the power take-off shaft is shielded on tractor diggers.

2. Provision is usually made for changing the vertical distance between the vine-turner shaft and the shaker. When it is necessary to set the shovel deep and the vines are heavy, the vine-turner shaft should be set as far away from the shaker as possible. This gives more room for the passage of

earth and vines. For light-digging conditions, better work will result if this distance is decreased.

3. The draft of the potato digger is heavy. The larger size requires four horses or a tractor to draw it. Three horses may be used on the smaller size of standard elevator diggers or, if the digging is not continued for long periods, two horses may handle the load.

Tongue trucks are used on the standard potato diggers. The wheels of the truck should be set parallel with the pole. There is an adjustment provided for this purpose on the tongue truck.

Special four-horse eveners are furnished with the large-sized diggers so that the horses walk between the rows.

4. The elevator rods should be kept at sufficient tension to operate properly. If too loose, the elevator may climb the sprockets, or it may sag down too much under a heavy load and the upper and lower sides may catch together. If the elevator is too tight, the unnecessary tension increases the draft. The tension is regulated by removing or adding rod links to the elevator as required.

5. The elevator supporting rollers are adjustable and should be regulated to carry the slack on the underside properly. On some makes of diggers the height of the front end of the elevator above the shovel is adjustable by means of the two front rollers. The best results in stony ground are secured with the front end of the elevator raised as high as possible.

When separation is difficult and extreme agitation is needed on the elevator, the position of the large and small agitators may be reversed. With the large agitators in the lower position, the movement of the elevator is increased.

Only under unusual conditions should the above change be made. The least agitation that will give satisfactory separation should be used. Particularly in digging early potatoes, the agitation given the elevator should be as little as possible. To lessen the agitation, put on a set of smooth rollers in place of one of the sets of agitating sprockets. An extra set of rollers is usually furnished with the digger for this purpose.

6. Start digging at one edge of the field. The shovel should be lowered while the machine is in motion. In some machines, lowering the shovel engages the pawls which drive the working parts. In others, it is necessary to engage them by hand. This is done by means of small latches carried near the center of the main wheels. In any case, the elevator should be in motion before the shovel enters the ground.

Drive across the field, keeping the digger astraddle of the row.

7. The shovel should be lowered just enough to get under all the potatoes. The depth is regulated by the shovel-lifting lever.

8. The pitch or downward slope of the shaker, under ordinary conditions, should be set so that the center bars just touch the ground. This adjustment will give the best rows of potatoes. If the potatoes are not well separated with this setting, the angle should be decreased or made less steep. This setting will give cleaner separation, but the potatoes will be scattered more widely.

Two holes are provided in the pitman cranks for setting the wrist pins which drive the shakers. One hole gives a greater throw or movement to the shaker than the other. Under conditions where separation is difficult, the hole with the largest throw should be used.

9. Raise the shovel at the end of the row. Turn the digger around and make the return trip on the third row, or on the third *pair* of rows with a two-row digger. One row, or *pair*, is skipped at each end of the field. This method allows the men gathering the potatoes the time to pick up those in the first few rows. Then the digger returns and digs the rows that were skipped. In this way there is little chance that the horses or tractor will injure the potatoes. Where a large crew of pickers is employed, it is a common practice to dig every row instead of alternate rows. This method is faster and requires less travel of the digger, but extra pickers are required to keep the path of the digger clear of potatoes.

Field Troubles

The principal troubles met in digging potatoes are caused by stones or by the heavy surface growth of vines, grass, weeds, etc. Because of the ridges, it is difficult to remove this heavy surface growth by mowing and raking it off before digging. In many instances, however, this can be done to advantage. When digging on such fields, the elevator should be given ample agitation and the vine-turner crank set high.

Stones are frequently a source of trouble. The stone trap mentioned on p. 363 eliminates this difficulty to some extent. The elevator should be kept tight enough to prevent stones from working in between the sprockets (or rollers) and the rod links. The operator will find it convenient, when digging on stony fields, to have a short iron bar with which to pry the elevator and release stones that in spite of all precautions may become wedged.

Hillside Operation. Digging potatoes from fields on sidehills is difficult. The digger slips downhill, and trouble is experienced in keeping it astraddle of the row. For this purpose, special lugs or spurs may be necessary. They are made so that one long face of each lug enters the ground in the best position to resist the side-slipping and hold the digger to its work.

Some types of diggers are regularly supplied with a T-shaped lug. One face of this lug gives forward traction; the other resists side-slipping.

A special lever for controlling the direction of travel of the tongue truck is supplied on some makes of diggers. This is a desirable feature and is particularly useful on hillsides.

Bruising. To prevent bruising the potatoes, the agitator rollers (Fig. 256) may be replaced with plain rollers or else one continuous elevator (Fig. 255) may be used.

CHAPTER XI

TRACTORS

The use of pneumatic tires has increased usefulness, speed, and efficiency and has made tractor operation more convenient and comfortable. Mounted tractor implements, controlled by mechanical or hydraulic power lifts, have brought further advantages and conveniences.

As a source of belt power, the tractor is used for an almost endless list of farm jobs.

Tractors are widely used in industry as well as in agriculture. Special types and models have also been developed for maintaining highways, parkways, golf courses, lawns, etc., and for work in orchards and groves.

The tractors used in agriculture may be divided into three classes, as follows:

1. Garden tractors.
2. Small or auxiliary farm tractors.
3. Farm tractors.

Garden Tractors

This classification includes tractors with engines as small as ½ horsepower and as large as 9 horsepower. Tractors with engines of 10 to 23 horsepower are considered small farm tractors. In many respects of course, these two classes overlap and an accurate definition of each is quite difficult. Also, there is great variation in the size and capacities of the various models in the same class. For instance, the smallest of the garden tractors are not capable of plowing, but the largest garden tractors will operate a 12-inch moldboard plow.

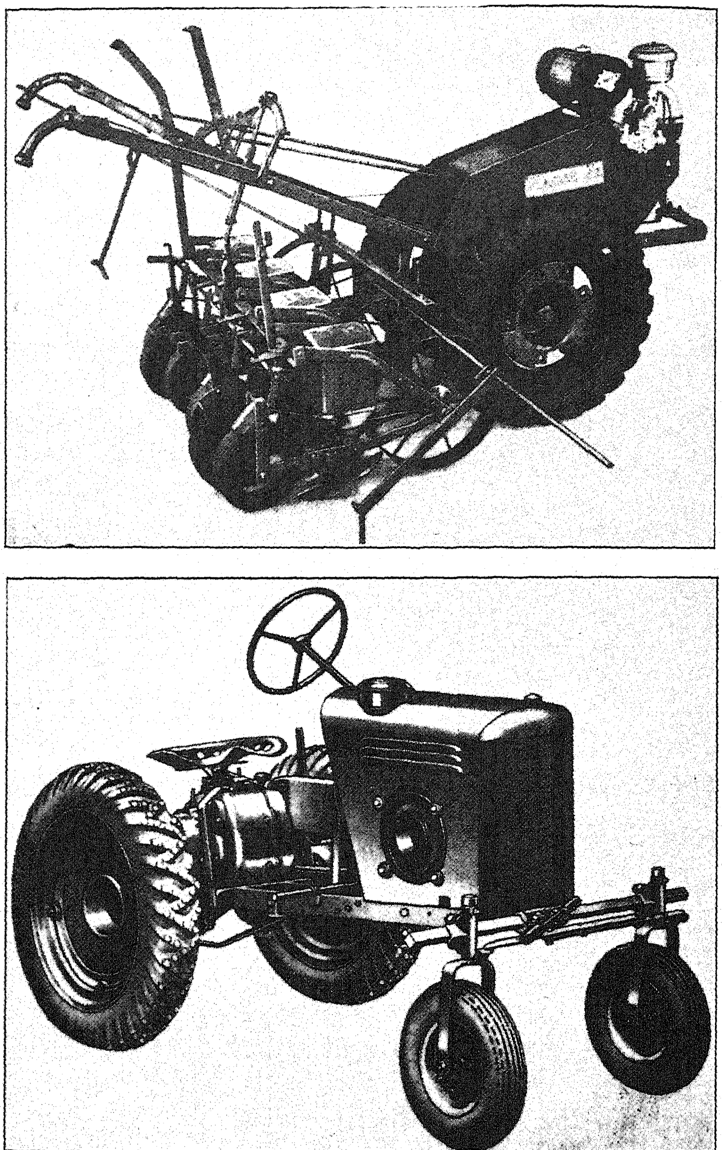


FIG. 262. *Upper*—Walking-model garden tractor with four-row seeder. *Lower*—Riding-model garden tractor.

SMALL FARM TRACTORS

Included in this class are tractors with engines of 10 to 23 horsepower, capable of operating two 14-inch (or smaller) moldboard plows. To set up the general specifications and descriptions which follow, a study was made of fifteen different

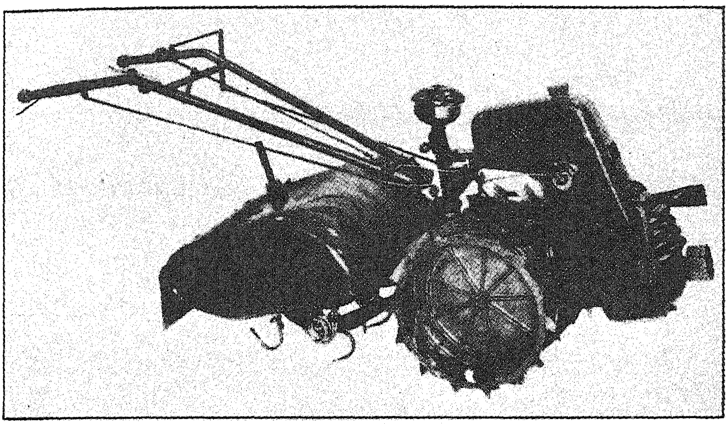


FIG. 263. Rotary-tiller garden tractor.

models. All machines studied are of the general-purpose type, that is, they are all adapted for cultivating row crops as well as for ordinary drawbar work such as plowing and harrowing. All may be equipped with pneumatic tires; all may have a full electrical system, including starter and lights; all are provided with belt pulley and power take-off (a shaft, extending from the tractor transmission, which carries engine power to the mechanism of the implement drawn by the tractor). Differential brakes for quick turning are standard equipment.

The fifteen models studied may be divided into two main groups or types:

1. *Three-wheel* (*Tricycle*) *Type* (Fig. 136). This type has wide tread of the rear wheels. Adapted especially for two-row cultivators, the rear wheels are spaced to straddle two rows.

In general, this class is the one best suited for farms where row-crop cultivating is the major enterprise. These machines are easily adapted to different row widths.

2. *Four-wheel Automotive Type* (Fig. 135). These are particularly adapted for single-row cultivating of field crops; they have suitable gear ratios for field work or for high-speed hauling for which an extra-high speed is usually provided. To some extent, the design may have been affected by the many "home-made units" built from used automobiles. At least, the popularity of this custom demonstrated the need and usefulness of such a light, fast-moving unit.

To a considerable extent, of course, one class merges with the other and no distinct division based on their capacities and capabilities is possible.

Most owners of small acreages depend upon one tractor to perform all their work. The tractor must, therefore, be a versatile, all-purpose type of machine. Operators of large farms or highly specialized enterprises may purchase a tractor for one specific operation, but the small farm owner or gardener must employ his tractor for a variety of purposes.

Large Farm Tractors

This class includes three distinct styles of construction: the standard four-wheel, the tracklayer, and the general-purpose (also called the row-crop).

Standard Four-wheel Type (Fig. 264). This type is the oldest type and was the most widely used until about 1930, after which the general-purpose became the most popular. The two front wheels are used for steering, and the rear wheels, which track with the front, are the drivers. In these respects, certain principles of automotive design have been followed. The tread or width between the centers of the rear wheels is usually 45 to 52 inches. In a few models the distance between drive wheels is variable.

The size, weight, and horsepower of the various models in

this class vary greatly. The smallest pull two 14-inch plows, weigh about 3500 pounds and have engines of approximately 25 belt horsepower. The largest-sized types weigh about 28,000 pounds and have engines of 130 or more horsepower. Tractors of the standard four-wheel type are used in all parts of the country for plowing, harrowing, and other field draft jobs, as well as for belt work, hauling, etc. This type is low,

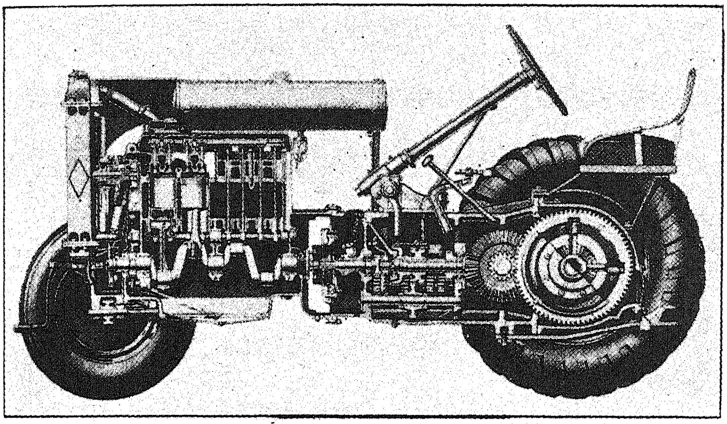


FIG. 264. Cutaway view of standard four-wheel farm tractor.

with little clearance beneath it. It is difficult to adapt for row-crop operations. Consequently, where row crops are a major enterprise, the general-purpose is the most in demand.

The orchard and grove tractor is a modification of the standard four-wheel type. Minor changes in the enclosure of the wheels, the addition of special fenders, branch deflectors, cowling, etc., lowering the steering wheel and seat in some models and removing all projecting parts—all help adapt the standard four-wheel models for work in orchards, groves, and vineyards. (See Fig. 265.)

The Tracklayer (Fig. 266). Tracklaying machines have been made since the first years of tractor production. The advantages offered by the endless track became evident when

it was used for military and industrial work, and it was generally used for such purposes before it was applied on farms. But the advantages of this type were soon found to be important in farm work also. The number of tracklayers now used on farms is substantial. Tracklayers afford good traction on soft or wet ground and on loose, sandy soil; they have a very

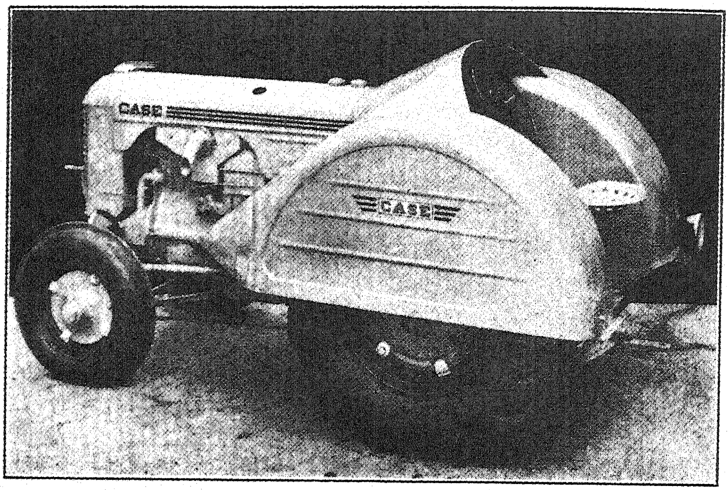


Fig. 265. Orchard-and-grove-type tractor.

short turning radius; their low center of gravity adapts them for work on rough or hilly land. The great area of contact between the trucks and the ground makes low pressure per square inch and lessens soil-packing.

Steering is accomplished in the tracklayers by special steering clutches which permit one track to be stopped and the other to drive or by a differential which through the action of brakes causes one track to drive faster than the other when turning.

The General-Purpose (Tricycle Type) (Fig. 136). This tractor is the most recent development. Their production attained commercial importance about 1926. They are frequently

referred to as "row-crop" tractors for they perform many row-crop operations such as planting, cultivating, spraying, and harvesting, as well as the field work accomplished by the two preceding types. Both wheel-type and track-type tractors are available in the general-purpose or row-crop design.

All general-purpose machines have greater clearance beneath the axle than other types; short turns are made possible by

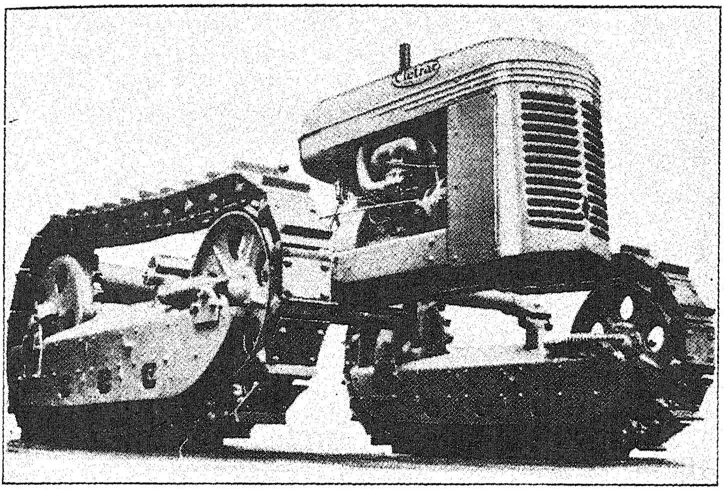


FIG. 266. Tracklayer tractor (general-purpose type).

differential brakes; all are designed to be operated as a one-man cultivating unit. Both wheel- and track-type, general-purpose tractors are produced with power take-off.

The development of the power take-off has had a decided effect upon farm implements and field operations. A long list of implements depending upon the power take-off for operation might be compiled: grain binders, mowers, corn pickers, potato sprayers and diggers, pulverizing plows, field ensilage cutters, and many other labor-saving machines. Then, too, the tractor has affected the design of farm implements; disk harrows, for instance, are made larger, stronger, and of better materials,

suitable for higher working speeds of the tractor. Disks of greater diameter are used in certain models, thus eliminating the necessity for plowing. Multiple-row corn cultivators and planters are in general use. Large field cultivators, chisels and subsoil plows, rotary hoes, rod weeders, wheatland disks, and various types of fallow implements have appeared. The growing popularity of the harvester-thresher combine is largely attributable to the tractor. It is interesting to note that, although in general the tractor has caused an increase in the size of farm implements, it has also resulted in popularizing smaller units of some machines such as threshers and combines, making it possible for the farmer to operate these implements with his own help instead of having to await his turn in a community enterprise.

CHAPTER XII

TRACTOR ENGINES

Internal-combustion engines are used in nearly all farm tractors. These engines operate on liquid fuels such as gasoline, kerosene, distillate, and fuel oil. The engine provides means for igniting and burning this fuel in such manner that a certain proportion of the heat obtained may be converted into useful power; the efficiency of the engine is determined by this proportion. Yet, no matter how nearly perfect the design and construction of the engine, the results obtained will depend in large measure upon the ability and thoroughness of the man who operates it and the care he gives it. Certainly, intelligent care and attention can be given only by one who clearly understands the construction and action of all the various engine parts.

Principal Engine Parts

Cylinders. The cylinder has often been referred to as the heart of the engine. Within it, the essential process of combustion takes place. In an internal-combustion engine, the burning of the fuel is not continuous, as in a steam engine, but intermittent. The liquid fuel is burned in small amounts or charges, each of which must first be vaporized and mixed with air; then admitted to the cylinder and compressed in order to burn more rapidly; next ignited and burned; and lastly the burned gases must be expelled from the cylinder. The process going on within the cylinder is made up of four distinct steps (see Fig. 267):

(*a*) Admission of fuel charge (suction stroke).
(*b*) Compression of fuel charge (compression stroke).

(*c*) Ignition and burning (power stroke).
(*d*) Expulsion of burned gases (exhaust stroke).

Most farm tractor engines have four cylinders, some have two, and some have six. No matter how many, these four events take place in each cylinder and always occur in the same order. Each cylinder is in reality a complete engine, but all draw their fuel from a common source and deliver their power to a common point. The large casting containing the cylinders is

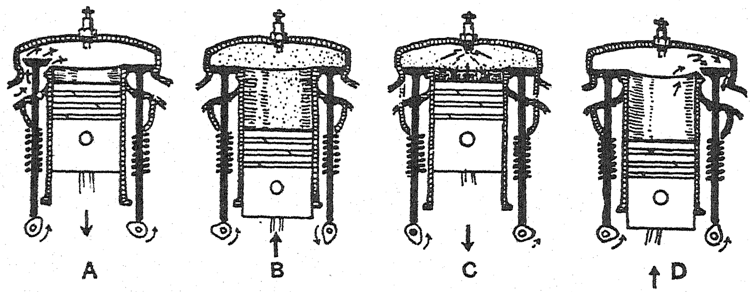


FIG. 267. The four strokes of the piston. *A*—Intake. *B*—Compression. *C*—Power. *D*—Exhaust.

called the *engine block*. All cylinders may be cast in the same block, in pairs, or singly.

Each cylinder forms an airtight chamber, closed at one end by the cylinder head and at the opposite end by the piston. Fuel is admitted to the cylinder and exhaust gas is expelled from the cylinder through passages or ports which are opened when needed by the action of valves. A transverse cross section of a typical tractor engine is shown in Fig. 264. Engines with cylinders placed vertically are the most common, although engines with horizontal cylinders are also used. Cylinders may be cast as a part of the engine block and then bored and finished to the exact size, or they may be made as a removable sleeve which is fitted into the engine block. In either case, cast iron is the material used. It withstands high temperatures without distortion, and may be easily machined and highly polished

so that the piston rings may be accurately fitted and will work freely within it.

Pistons. The piston moves up and down within the cylinder and makes possible the accomplishment of the four distinct events occurring within the cylinder. This "up and down" or reciprocating motion is caused by the connection of the piston with the crank shaft.

Intake of Fuel to Cylinder. As the piston moves downward or away from the cylinder head, it creates a partial vacuum within the cylinder. A valve called the *intake valve,* located in the passage connecting the cylinder to the supply of fuel mixture, is then opened, and the fuel mixture is forced into the cylinder by atmospheric pressure.

Compression of Fuel Mixture. When the piston begins its upward stroke, the intake valve closes and thus the fuel mixture is trapped in the cylinder. When this upward stroke is completed, the fuel mixture has been compressed into a space about one-fifth what it occupied at the end of the intake stroke. The pressure on the fuel mixture thus confined and also its temperature have greatly increased, so that when ignited it will burn rapidly and forcefully.

Power Stroke of the Piston. Just after the fuel mixture is fully compressed, it is ignited by an electric spark, the current for which is generated and delivered by the ignition system (Chapter XIV) at the proper "time," or just as the piston is in the proper position, near the end of its compressing stroke. The expansion of the burning fuel causes a high pressure within the cylinder, and forces the piston downward or away from the cylinder head again. It is this second downward stroke of the piston that gives power and starts the engine running. This one power stroke (in a single cylinder engine) must store enough energy in the crank shaft and flywheel to move the piston through the remaining three strokes, as well as to supply power for the work to be performed by the engine.

Expulsion of Burned Gases. After one charge of fuel mixture has been consumed, it is necessary to clean out the cylinder and remove the burned gases (carbon dioxide, water vapor, etc.) before another charge can be admitted. Accordingly, on the second upward stroke of the piston, the exhaust valve is opened and the burned gases are pushed out. When the exhaust stroke is finished, the cycle begins again with the intake of a fresh fuel charge.

Pistons for tractor use are usually made of cast iron, but in automobile engines, where light weight and high engine speeds are required, the pistons are often made of lighter metals such as alloys of aluminum.

The position reached by the piston at the upper limit of its stroke (nearest the cylinder head) is referred to as *top center*, and the lower limit (farthest from the cylinder head) is called *bottom center*. The stroke of the piston is the distance in inches from top to bottom center.

The explanation of the operation of the four-cycle engine may be summarized and graphically represented by means of a spiral timing diagram. It should be remembered that the actual position of the crank for the valve and spark events will vary somewhat with every engine, but the positions indicated in the accompanying diagram are typical. It is recommended that those who are operating engines make a similar diagram for the engine or engines that they are particularly interested in. The necessary information may generally be obtained from the instruction book or from the timing marks on the flywheel.

In Fig. 268, the upper end of the vertical line represents top center; the lower end, bottom center. The spiral line represents the travel of the crank through the four strokes, or two revolutions. The various events are indicated on this line as they occur, with reference to the corresponding crank, and consequent piston positions.

Work Stroke. Starting at top center at the beginning of the work stroke, the expanding gases push the piston out tc the point of the exhaust opening, 45 degrees before bottom center. As the exhaust gases rush out, the pressure within the cylinder rapidly

falls but still is sufficiently above atmospheric pressure to exert a slight force against the piston until it reaches bottom center. The duration of the work stroke is indicated by the full black line.

Exhaust Stroke. The exhaust stroke begins, with the opening of the exhaust valve, 45 degrees before bottom center, and continues throughout the following half revolution of the crank and 10 de-

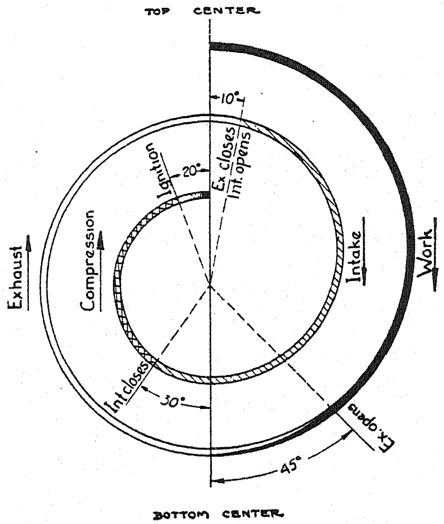


FIG. 268. Diagram of the four strokes of the piston.

grees past top center, as previously explained. The duration of this stroke is represented by the open line.

Intake Stroke. The intake stroke immediately follows the exhaust stroke, and extends to 30 degrees past bottom center. The duration of this stroke is represented by the cross-hatched line.

Compression Stroke. The compression stroke immediately follows the intake stroke, and extends to the point of ignition, 20 degrees before top center. The duration of this stroke is represented by the double-cross hatched line.

Combustion occurs between the time of ignition and top center. The cycle of operations has been completed in four strokes, and will be repeated always in this order.[1]

[1] Cornell Extension Bulletin 85.

Piston Rings (Fig. 269). The pistons must be made slightly smaller in diameter than the cylinders, to allow them to move freely and to expand when heated. Piston rings are used to prevent leakage past the piston and to make a tight connection between the cylinder and piston. The rings are cut to move freely and to expand when heated. Piston rings are used to prevent leakage past the piston and to make a tight connection between the cyclinder and piston. The rings are cut from a cylindrical iron casting or cast separately, then machined and finished to exact size. A cut is made through the ring at one point, removing some of the metal. Because of this construction the rings are compressed when in place and act like an expanding spring, pressing outward against the cylinder walls. The rings are carried in grooves cut around the piston and may be replaced with new ones when worn.

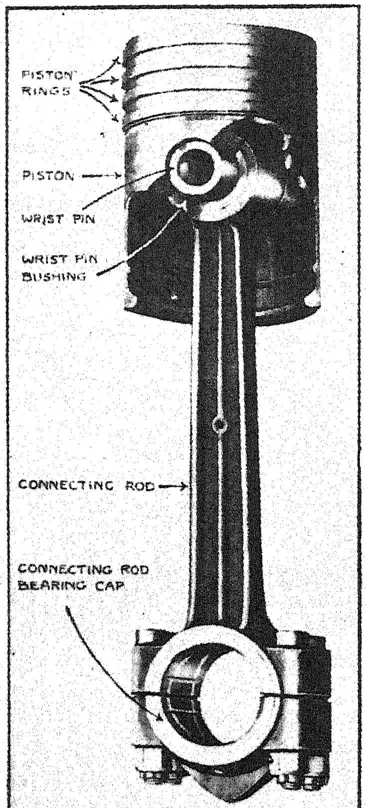


FIG. 269. Piston and connecting rod assembled.

Cylinder Head (Fig. 270). The upper ends of the cylinders are closed by the cylinder head which is securely bolted down to the engine block. To make a tight fit between the engine block and cylinder head, a copper and asbestos gasket called the *cylinder-head gasket* is

used between them. Water circulates around the cylinders and passes upward through holes in the gasket into the cylinder head, to prevent these parts from overheating. It is important that this gasket be kept tight and in good condition, as it is subjected to the force of the compression within the cylinder, the heat and pressure of combustion, and the constant flow of hot water through it.

Wrist Pin (Fig. 269). A hollow, cylindrical, steel pin called the wrist pin attaches the piston to the connecting rod.

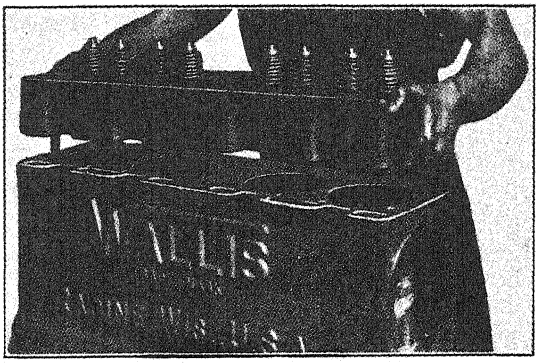


Fig. 270. Cylinder head, cylinder-head gasket, and engine block.

The wrist pin is usually secured to the piston with a setscrew, or is clamped in the upper end of the connecting rod with a bolt.

Connecting Rod (Fig. 269). The pressure on the piston is transmitted to the crank shaft by the connecting rod, which attaches the piston and wrist pin to the crank shaft. High-carbon, heat-treated steel is used in making the connecting rod, since it is subjected to severe shocks whenever the engine is running. The upper end of the connecting rod is fitted with a bronze bushing, or is clamped to the wrist pin as described in the preceding paragraph. The lower end is split so that the bearing cap may be removed when the rod is being assembled to the crank shaft. Babbitt bushings or liners are used in the

lower end of the connecting rod, to bear against the hard steel of the crank shaft. After being placed on the crank shaft, the bearing cap is drawn up with the connecting-rod bolts. Brass shims may be provided between the halves of the bearing, which may be removed as required to "take up" or tighten the bearing when it becomes worn. Adjusting the lower connecting-rod bearings is frequently necessary; it is fully described on p. 503.

Crank Shaft (Fig. 271). The power imparted to the piston is transmitted to the crank shaft through the wrist pin and

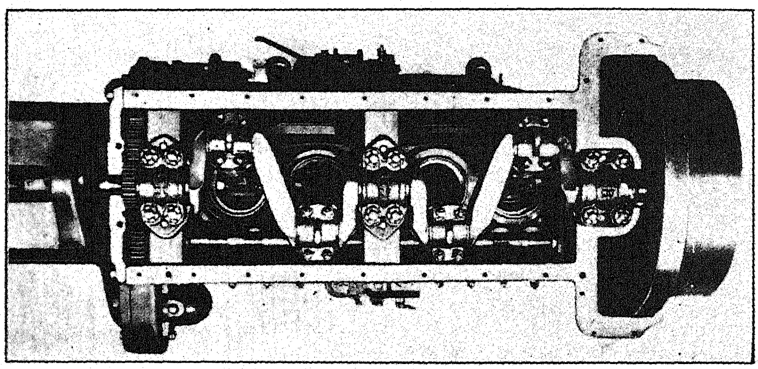


FIG. 271. Bottom view of engine.

connecting rod. The crank shaft is the largest and heaviest shaft in the engine. It is a drop-forged, heat-treated shaft made of high-carbon steel which is usually toughened by the addition of nickel. It transforms the reciprocating movement of the piston into rotary motion which is easily transmitted to the drive wheels, belt pulley, or power take-off (p. 472). The crank shaft is carried in large, babbitt-lined bearings called *main bearings*. These are constructed in halves, similar to connecting-rod bearings, and are adjusted in much the same manner. (See p. 505.) Three bearings are usually provided for the crank shaft of four-cylinder tractor engines.

The rear end of the crank shaft is flanged, and the flywheel

is bolted to this flange. A small gear called the *crank-shaft gear* is keyed to the front end of the crank shaft. Power is taken from this gear for driving the camshaft, which operates the valves, magnetodriving shaft, water pump, etc.

Valves. Each cylinder usually has two valves. One called the *intake valve* admits fuel mixture, and the other called the *exhaust valve* permits burned gases to escape. Poppet valves like those shown in Fig. 274 are used in tractor engines. There

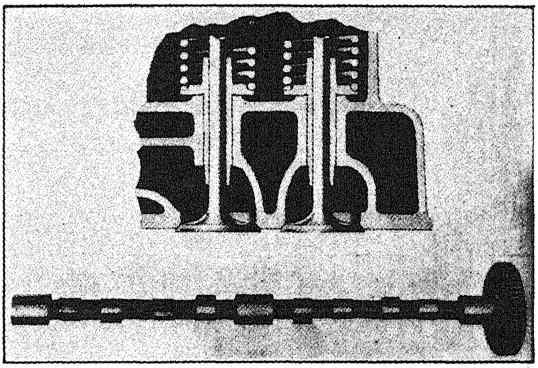


FIG. 272. *Upper*—Valves, valve guides, and valve springs. *Lower*—Camshaft and camshaft gear.

are two common methods of placing valves. One is called the *valve-in-head arrangement*, shown in Fig. 270. Here all the valves are carried in the cylinder head, directly above the cylinder. In the other arrangement called the *L-head*, all the valves are carried in the engine block at one side of the cylinders, as shown in Fig. 274. Still another valve arrangement called the *T-head* is sometimes used as indicated in Fig. 267. This arrangement requires the use of two camshafts.

Valve Operating Parts. Proper action of the valves is essential to the efficient operation of the engine. Each valve must open just as the piston reaches a certain point in its stroke, must open or "lift" to the proper height, and must

also close tightly when the piston reaches another definite position in its travel. The process of controlling or setting the valves so that they act at the correct piston position is called *valve timing* and is discussed on p. 390.

1. *Camshaft* (Fig. 272). The camshaft of a four-cylinder engine is supported by three non-adjustable bearings carried in the engine block. Its location, above and at one side of the crank shaft, may be noted in Fig. 271. It is made from one solid piece of steel and is hardened and heat-treated. The raised pieces on the shaft are called *cams*. The camshaft for a four-cylinder engine has eight cams, one for each valve. The high portion or point is the toe, and the low part the heel of the cam. The cams operating the exhaust valves have broader toes or points than those operating the intake valves because the exhaust valves are opened for a longer period than the intake valves.

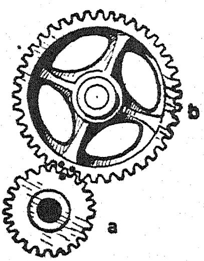


FIG. 273. Timing gears.

The camshaft gear at the front of the shaft meshes with and is driven by the crank-shaft gear. The camshaft revolves only half as fast as the crank shaft, for its gear has twice as many teeth as the crank-shaft gear. These gears are called the *timing gears* and are marked so that they may be meshed at the proper point, since the relation of these two gears controls the timing of the valves. (See Fig. 273.) The revolving of the camshaft gives the lifting action necessary to open the valves.

2. *Valve Tappets* (Fig. 274). The lifting action of the cam is transmitted to the valve tappet, which is free to move up and down in its guide. The tappet in turn presses against the lower end of the valve stem and pushes the valve open.

3. *Valve Springs*. A heavy coil spring surrounds the stem of the valve and causes it to close when the toe of the cam turns away from the tappet. These springs are depended on to hold the valve tightly closed during the entire time that the

flat portion of the cam is against the tappet. Proper closing of the valves is vital, and the springs must be replaced if they become weakened.

4. *Tappet Adjusting Screw.* When the engine is cold and the cam is in the position shown in Fig. 274, there should be a slight air space or clearance between the end of the valve stem and the head of the adjusting screw. When the engine is hot, the valve stem lengthens. Were it not for this clearance, the end of the stem would always rest on the tappet and the valve would not close tightly. Accurate adjustment of this clearance is made possible by the tappet adjusting screw. This adjustment called the *valve-stem clearance* must be tested frequently. (See p. 501.)

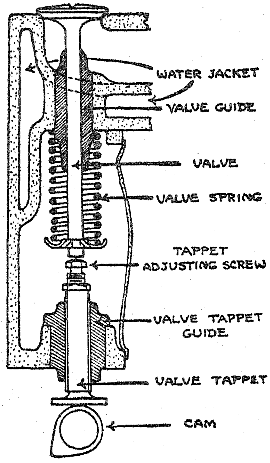


Fig. 274. Valve operating parts.

5. *Push Rods and Rocker Arms* (Fig. 312). On valve-in-head engines, two other valve-operating parts are necessary in addition to those mentioned above, as in this type the valves are not directly above the camshaft. Also, they are assembled in an inverted position. These additional parts are the push rods and the rocker arms. The screw for adjusting the valve-stem clearance is located in the rocker arm.

Flywheel. The flywheel is bolted to the flange at the rear of the crank shaft. It acts as a balance wheel to make the engine run evenly, and in most tractor engines the rear face of the flywheel is recessed to receive the clutch.

Crankcase. The crank shaft is fully enclosed in an oiltight housing, part of which is made up of the lower portion of the engine block, or that portion below the cylinders.

The crankcase enclosure is usually completed by the addition

of a removable oil pan and reservoir (Fig. 275) which is attached to the bottom of the engine block. This holds the oil supply for the engine, and the oil pump is attached to it or immersed in the oil within it. Petcocks are used in many engines for indicating the quantity of oil in the reservoir, although other types of oil gauges are also employed.

The parts described in the foregoing pages comprise the basic parts of the tractor engine, but many other parts and

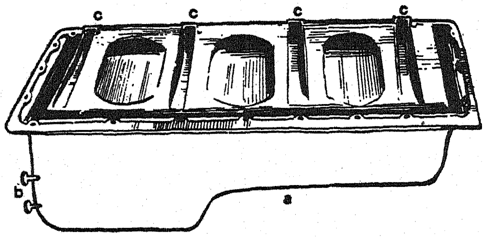


FIG. 275. Crankcase oil pan and reservoir.

mechanisms are necessary to complete it. The remaining parts, however, may be best described according to their special functions, such as ignition, cooling, carburetion, lubricating, etc. Accordingly, each such group is given separate treatment in the following chapters.

JOB 22

FIRING ORDER AND VALVE-TIMING OF A FOUR-CYLINDER ENGINE

Procedure

1. Remove the cover or inspection plate enclosing the valves. This will expose the valve stems and springs. In valve-in-head engines, this cover is at the top of the engine; in L-head engines, it is located at one side.

2. Determine which are intake and which are exhaust valves. One good method for this is to crank the engine and watch the action of the two valves in any one cylinder. It will be noted

that the intake valve opens almost at the same time that the exhaust valve closes.

Use the same method to distinguish between the intake and exhaust valves in the remaining cylinders. What means is provided for adjusting the valve-stem clearance? (See p. 501.)

3. Remove the spark plugs. Crank the engine slowly until the intake valve in cylinder 1 begins to open. Cylinders, if

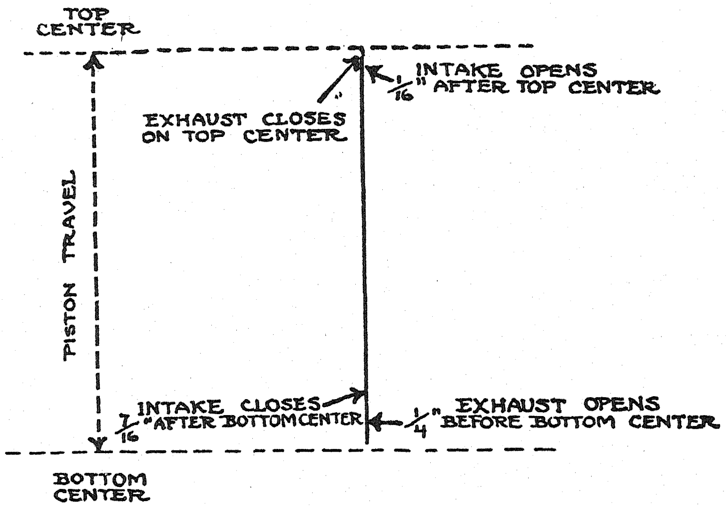


FIG. 276. Linear valve-timing diagram.

placed vertically, are numbered in direct order, beginning at the front end of the engine. Continue to crank the engine slowly, and notice the order in which the intake valves in the remaining cylinders open. The power strokes occur in the same order as the valves open, and hence this is called the *firing order*.

4. Crank the engine until piston 1 is about one-fourth down on its intake stroke. Determine which stroke each of the other pistons is making at this time.

5. How many revolutions of the crank shaft are required to

cause any one piston to complete all four strokes, namely, intake, compression, power, exhaust?

6. How many revolutions of the crank shaft are required to cause all the pistons to complete all four strokes? If the crank shaft of a four-cylinder tractor engine is revolving at

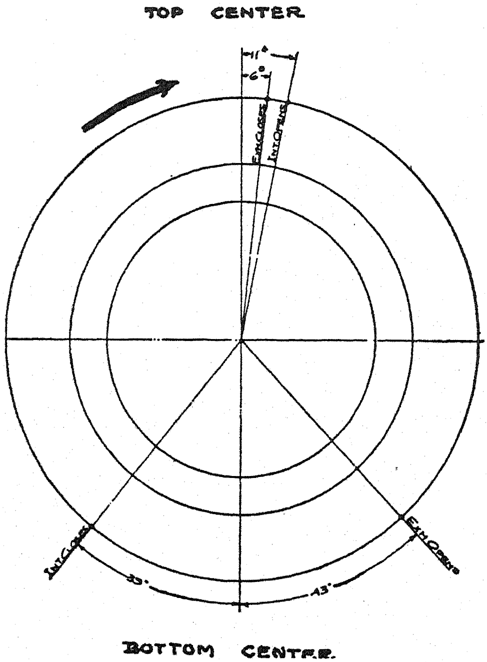


FIG. 277. Angular valve-timing diagram.

1000 revolutions per minute, how many power impulses are received by the crank shaft pér minute?

7. Crank the engine over slowly until any one intake valve just begins to open. Where is the piston? Is it on top center or just past top center? (The position of the piston may be determined by putting a wire or thin, flexible rod through the spark-plug hole, letting it rest on top of the piston.)

8. Crank until the intake valve closes. Where is the piston

now? Is it on bottom center or is it past bottom center and moving upward?

9. Crank until the exhaust valve just begins to open. Where is the piston?

10. Crank until the exhaust valve closes. Where is the piston? Record these positions carefully and prepare a valve-timing

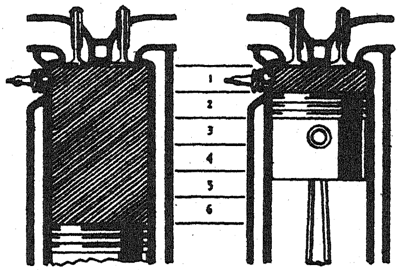


FIG. 278. Compression ratio of 6 to 1.

diagram similar to that shown in Fig. 276, which expresses valve-timing positions in linear measurement of piston travel (with relation to top or bottom center).

Valve-timing positions may also be expressed with angular measurement of flywheel rotation, as shown in Fig. 277.

11. Answer the following questions:

(*a*) When the intake valve is open, which one of the four functions of the piston is being accomplished?
(*b*) When the exhaust valve is open, which one of the four functions of the piston is being accomplished?
(*c*) Why are both valves closed on the compression stroke?
(*d*) Why are both valves closed on the power stroke?

ENGINE-COMPRESSION RATIOS

The ratio of the space within the cylinder when the piston is at the bottom of the intake stroke to the space when the piston has finished compression stroke is called the *compression ratio*. A ratio of 4.2 to 1.0 is considered low com-

pression and 5.5 to 1.0 (or higher) is considered high compression in tractor engines.

Low-compression tractor engines are used for burning heavy fuels such as kerosene or distillate; high compression, where gasoline is used exclusively. Low-grade fuels cannot withstand high compression without knocking or detonating ("pinging").

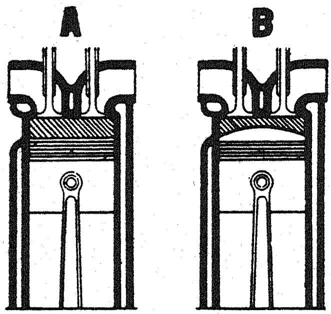


FIG. 279. *A*—Low-compression piston. *B*—High-compression or "altitude" piston.

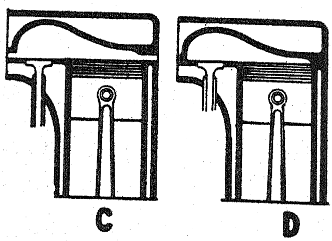


FIG. 280. *C*—Low-compression cylinder head. *D*—High-compression cylinder head.

Almost all regular gasoline today has been treated with tetraethyl lead, which enables it to withstand the higher compressions without knocking.

If gasoline is to be used most efficiently, a high-compression engine is essential. Some manufacturers furnish either high- or low-compression engines. It is comparatively easy to change an engine from low to high compression (Fig. 279). The change may require (1) "altitude" pistons, (2) a high-compression cylinder head, (3) a "cold" manifold, and (4) a "cold" type of spark plug.

DIESEL ENGINES

Their efficient use of low cost fuels and the ability to handle heavy loads economically have caused manufacturers to furnish Diesel engines in many of the larger sizes of farm tractors.

The construction of the Diesel is similar to the standard spark-ignition engines already described. The four piston strokes, described on p. 381, also take place in tractor Diesel engines, but on the first downward intake stroke, air only is drawn into the cylinder. The air is so heavily compressed (16 to 1 ratio) by the first upward piston stroke that its temperature (approximately 1200° F.) is far above the burning point of

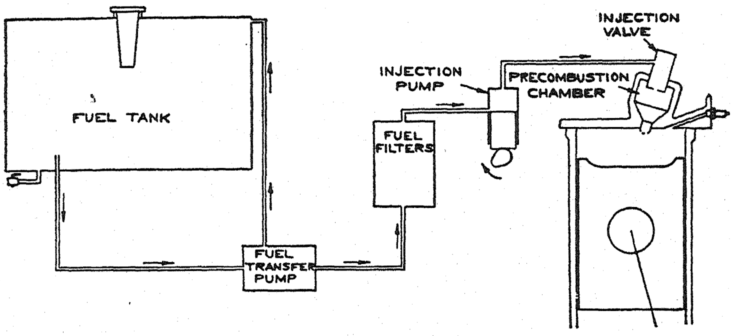


FIG. 281. Diesel engine fuel system.

the fuel. When compression is completed, the fuel is injected into the cylinder and ignited by the compressed, heated air. Thus no special ignition system is required.

The burning fuel forces the piston down on the power stroke as in the gasoline engine, and the second upward piston stroke drives out the burned gases.

The parts of a Diesel fuel system are shown in Fig. 281.

Two-cycle Diesel engines are also used in tractors. In the two-cycle type the four events—admitting, compressing, burning, and expelling—are accomplished by two strokes of the piston, instead of four as in the four-cycle type.

An explanation of the action of the two-cycle Diesel is reproduced here as given by the manufacturer.[1] (See Fig. 282.)

The pumping action of the 4-stroke cycle principle (exhaust and

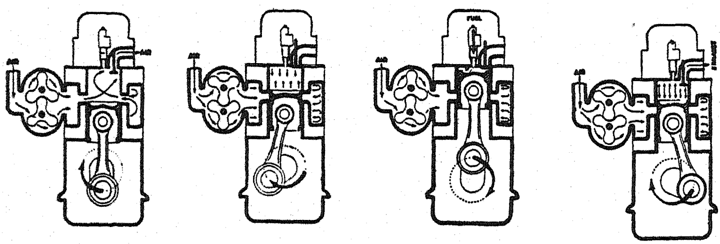
[1] Courtesy of General Motors Corporation.

intake strokes) is replaced in the GM 2-cycle Diesel engine by the operation of a blower, using a uniform scavenging system.

The blower provides a supply of air under pressure to the air chamber surrounding the engine cylinders.

A. At the lower end of the stroke, the piston uncovers port openings into the cylinder allowing fresh air to rush in, sweep the remaining exhaust gases out through the two exhaust valves in the cylinder head and completely fill the cylinder with clean air.

B. The exhaust valves close and the piston moves upward compressing the air to about one-sixteenth of its initial volume. Air



A, *B*, *C*, *D*

Fig. 282. Action of two-cycle Diesel engine.

when compressed to this extent increases in temperature to about 1000 degrees Fahrenheit—the temperature of red hot iron.

C. At this point fuel atomized by exceptionally high pressure is introduced. It is ignited by the high temperature of the air and continues to burn as injection continues. The duration of injection is predetermined by the governor which controls the amount of fuel required to maintain a given speed and load condition.

The burning charge rapidly builds up the pressure. This confined energy acts upon the piston forcing it downward on the power stroke.

D. Upon the completion of the useful part of the power stroke, the exhaust valves open, releasing the gases through the manifold to the atmosphere. The piston then uncovers the air inlet ports. By this time the exhaust gases have expanded so that the pressure is less in the cylinder than in the air chamber. The air therefore rushes in, completes the scavenging and the cycle is repeated.

CHAPTER XIII

CARBURETION SYSTEM

The liquid fuel burned in the tractor engines should be clean and carefully strained before it enters the engine. Before the fuel can be burned, it must be changed from liquid to vapor. The fuel vapor must then be mixed with a certain

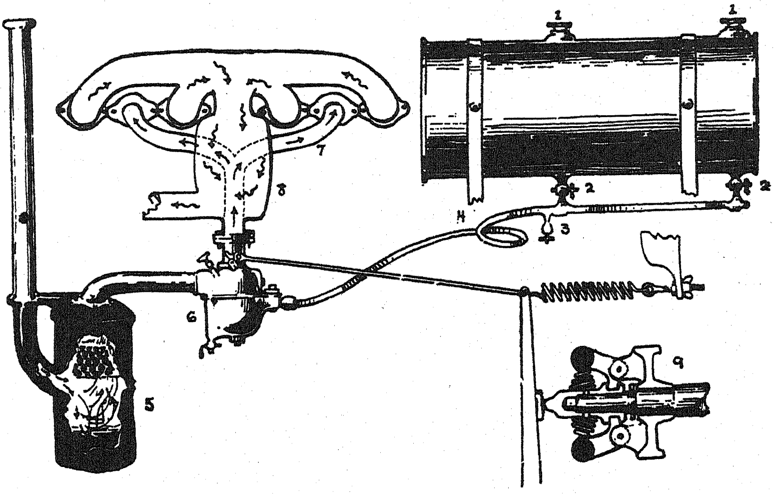


FIG. 283. Parts of the fuel system. 1—Fuel tanks. 2—Fuel tank valves. 3—Sediment bulb. 4—Fuel pipe. 5—Air cleaner. 6—Carburetor. 7—Intake manifold. 8—Heating device. 9—Governor.

amount of air. If the proportion of air to fuel is wrong, the mixture will not burn readily and the engine will lose power.

Tractors work in the dusty fields. If dusty air were drawn directly into the cylinders, the engine would soon be worn out. The air to be mixed with the fuel vapor must be washed or strained.

Fuel Tanks (Fig. 283). The fuel tanks are made of galvanized iron. If the engine is designed for heavy fuels, there are two tanks, or two compartments in one tank, the smaller one for gasoline and the larger for kerosene or other heavy fuel. Gasoline is used to start the engine. When the engine has been warmed up, kerosene can be used. The engine cannot be started on kerosene. Engines designed for gasoline only have but one fuel tank.

Fuel-tank Valves. The fuel-tank valves are directly below the tanks. They may be closed to shut off the flow of fuel from the tanks to the carburetor. Some tractors have two shut-off valves, one under the gasoline tank and one under the kerosene tank. Others have a three-way valve such as shown in Fig. 284.

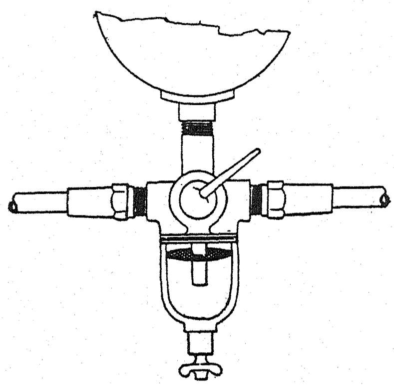


FIG. 284. Three-way fuel valve and sediment bulb.

Fuel Pipes. The fuel pipes are small copper tubes. They allow the fuel to flow from either tank to the carburetor.

Sediment Bulb. The sediment bulb is a small bowl containing a fine wire strainer. All the fuel must pass through this strainer which removes all dirt and sediment. The sediment bulb is constructed so that any water in the fuel will gather in the bottom of the bulb and may be drawn off by the drain cock.

Filler Caps. The filler caps screw into the top of each tank.

The fuel is poured in through them. Each cap has a small air hole, which must be kept open. If the air holes become closed, the fuel will not flow down to the carburetor.

Throttle. The throttle is described as a small disk in the carburetor, where the carburetor is attached to the intake pipe. This may be closed or opened to regulate the amount of fuel mixture entering the cylinders. In this way, the setting of the

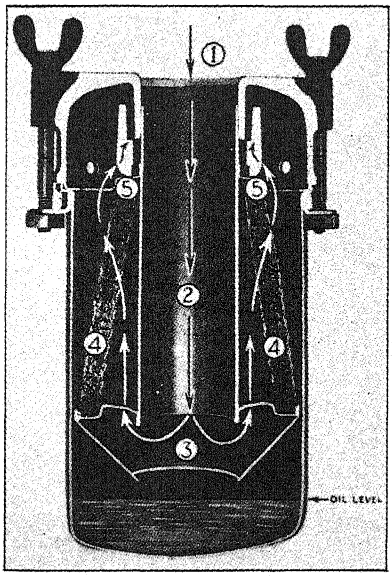


FIG. 285. Oil-type air cleaner.

throttle controls the speed of the engine. The throttle is operated by the driver of the tractor, with a small lever placed near his seat, or it may be controlled automatically by the governor.

Air Cleaners. The air cleaner is an essential part of the fuel system. Extreme care should be exercised to prevent dirt and field dust from entering the engine. Such material is highly abrasive, and when drawn into the cylinders, unites with the oil in the cylinder walls to form a grinding compound that causes rapid wear of the cylinders, pistons, piston rings, etc. Some will enter the crankcase, mix with the oil and be forced

into the engine bearings, causing bearing failure. In addition, the carbon formation commonly deposited on the combustion-chamber surfaces is made up chiefly of dust and gritty particles which are drawn through the air intake of the carburetor.

The length of service given by a tractor engine depends largely upon the proper functioning of a well-designed air cleaner. As tractor engines usually operate under extremely dusty conditions, under full load, with wide-open throttle, most of the air cleaners used on tractor engines combine several methods or stages of cleaning. The first cleaning is obtained by the coarse mesh at the top of the air entrance, or air stack. This excludes leaves, trash, etc. The second cleaning is done by oil.

The entering air stream is so directed that it impinges against a pool of oil in the bottom of the cleaner. Then the air reverses its direction and moves upward through the filter. A large proportion of the dust and practically all the heavier particles are caught in the oil, the remainder being intercepted by the filter.

Both the oil containers and the filters are easily removed for cleaning and renewing the oil supply.

The action of the type shown in Fig. 285 is as follows:

1. Dust-laden air enters cleaner from chimney or stack (not shown).
2. Column of dirty air passes downward through central tube.
3. Dust-laden air enters oil chamber and, owing to impact and sudden reversal, most of dust is thrown into the oil and settles to the bottom.
4. Partially cleaned air passes upward into the second-stage cleaner where all remaining dust is caught by the oil-wetted filter.
5. Perfectly cleaned air flows to carburetor intake.[1]

Danger from fire caused by backfiring through the carburetor is also largely eliminated by the air cleaner.

Carburetors

Function of the Carburetor. The efficiency of any engine

[1] A. C. Spark Plug Co.

depends in great measure upon the carburetor. It prepares the fuel so that combustion within the cylinder may be rapid and complete. The work of the carburetor consists in:

1. Atomizing and vaporizing the liquid used for fuel.
2. Mixing the fuel vapor thoroughly with the air.
3. Regulating the relative proportions of fuel vapor and air to suit the varying requirements of the engine.

1. *Vaporizing.* The liquid fuel must be changed to a vapor before it can be mixed with air to form a combustible mixture. Rapid vaporization is necessary in high-speed engines. The liquid is partially vaporized by being drawn through a small orifice or jet which acts like a spray nozzle, breaking up the liquid into a fine mist or spray. This spray is delivered into a rapidly moving stream of air which is passing through a heated tube or pipe leading to the cylinder. Hot exhaust gases escaping from the cylinder are usually directed around the outer walls of this pipe, thus supplying heat to complete the vaporization. Other means of supplying heat may also be used.

Vaporization is effected by all three of these factors—the spraying or atomizing at the jet, the velocity of the air past the jet, and the temperature within the pipe or tube conducting the mixture of fuel vapor and air to the cylinder.

2. *Mixing.* Good combustion requires the fuel vapor and air to be thoroughly mixed, so that the charge within the cylinder will be of uniform strength throughout all parts of the combustion chamber. Mixing is accomplished largely within the carburetor. By narrowing the air passage where the air meets the spray issuing from the jet, the velocity of the air at this point is increased. This construction is called the *Venturi tube.* It strengthens the atomizing action of the jet and causes the spray to spread well into the passing air stream.

Mixing is continued, however, within the intake pipe, and also within the cylinder, until the mixture is ignited; in fact, cylinder heads are especially designed to continue this mixing process within the combustion chamber.

3. *Proportioning.* Regulating the proportions of fuel vapor

and air is perhaps the most complex part of the work of the carburetor. The mixture required is not constant but varies according to the operation conditions. At idling speed a mixture in which the weight of the air is about twelve times that of the fuel vapor is required for best results. When the full power of the engine is needed for heavy loads or maximum speeds, a mixture of approximately 14 to 1 is effective. For light loads and for the greatest economy of operation, a mixture of approximately 16 to 1 is desirable.

To obtain these proportions, one or more adjustments are provided, which must be correctly set by the operator. In addition to these manual adjustments, carburetors are equipped with some means by which the strength of the mixture is automatically regulated. This automatic regulation is inherent within the carburetor and not subject to adjustment by the operator. (See pp. 407 and 410.)

Quick acceleration of the engine speed requires a momentary richening of the mixture. Some carburetors are equipped with a special device for quick acceleration. This facility is not especially important in tractor work, and tractor carburetors are not always provided with an accelerating device.

Basic Parts of the Carburetor. All carburetors are similar in construction to the extent that they possess, in some form, the basic parts shown in the simple carburetor in Fig. 286.

1. *Spray Nozzle or Jet.* When the piston begins its intake stroke, a partial vacuum is created within the cylinder; and when the intake valve opens, air rushes through the intake pipe to fill this vacuum. The movement of the stream of air past the jet (*c*) lowers the pressure there. This liquid is forced out through the small opening in the tip of the jet, because full atmospheric pressure is exerted upon the liquid in the float chamber, through the air vent provided in the top of the float chamber.

2. *Venturi Tube.* The air passage is narrowed down at the point where the air stream passes the jet. As already mentioned, this is called the Venturi tube construction. It is used in all

carburetors and makes possible better atomizing at the jet, as well as more complete mixing of the fuel vapor and air.

3. *Proportioning Adjustments.* The valve shown at *b* is a manual adjustment by which the rate of flow of liquid to the jet may be regulated. These adjusting valves are commonly called *needle valves* because of their pointed end. Manual adjustments may be provided as a means of regulating either the amount of fuel or the amount of air entering the mixture.

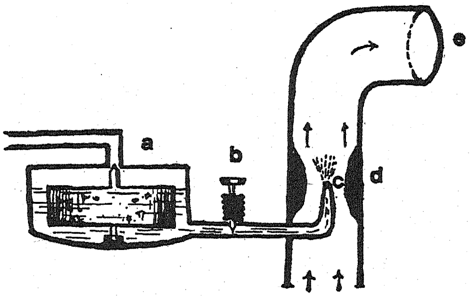


FIG. 286. Basic parts of a simple carburetor. *a*—Float and float chamber. *b*—Fuel needle valve. *c*—Jet. *d*—Venturi tube. *e*—Intake pipe.

Many carburetors have no manual proportioning adjustment except one for idling speed.

4. *Float and Float Chamber.* Gasoline enters the carburetor through the float valve *a*, and accumulates in the float chamber which contains a cork or hollow metal member. As the amount of gasoline increases within the float chamber, this float rises and closes the valve carried above it, stopping the incoming flow. The level of the liquid in the float chamber determines the level within the jet, and the float mechanism is adjusted so that the float valve will close when the fuel level is just below the tip of the jet. The purpose of the float construction is to maintain the correct supply of liquid fuel at the jet for all operating conditions.

5. *Air Shutter or Choke.* A shutter is provided at the point where the air enters the intake pipe by which the air passage

may be partially or completely closed. When a cold engine is started, very little of the fuel drawn from the jet is vaporized because of the low temperature within the intake pipe. In order to get enough fuel vapor to make a combustible mixture, an unusually large amount must be delivered from the jet. Closing the air shutter or choke while the engine is cranked increases the vacuum within the cylinder and intake pipe, making a greater difference between the low pressure at the jet and the atmospheric pressure on the float chamber. Accordingly, the amount of liquid sprayed out of the jet is greatly increased, giving a sufficient supply of fuel vapor for starting. As the engine warms up, the choke is returned to its normal open position. Excessive use of the choke causes dilution of the oil in the engine crankcase.

6. *Automatic Proportioning Device.* As the engine speed increases, the amount of fuel vapor forced from a jet of the type shown in Fig. 286 becomes too great for the amount of air. A mixture too rich for good combustion will result unless this tendency, which exists in all spray-type carburetors, is offset or compensated in some way.

Speeding up the engine increases the discharge of fuel from the jet. More fuel is thrown out than is needed for a good mixture. The velocity of the air passing through the carburetor has also increased with the speed of the engine. Air is elastic, and is pulled apart by the sudden increase in its velocity through the carburetor. Thus the air entering at high engine speeds is less dense and is unable to supply sufficient oxygen for the combustion of the increased amount of fuel vapor.

Automatic proportioning is accomplished either by increasing the amount of air or by curtailing the amount of fuel vapor entering the mixture at high engine speeds. A simple type of proportioning device consists of a spring-controlled air valve. At low engine speeds this valve is closed by the tension of the spring, but as the speed increases the valve opens, admitting more air.

More efficient methods of automatic proportioning are described on pp. 407 and 410.

7. *Throttle.* A small metal disk called the *throttle* is placed within the carburetor, as shown in Fig. 286. It is located well above the jet and Venturi tube and is used to regulate the amount of mixture passing into the cylinders. The position or setting of the throttle may be varied by the operator as desired, in order to regulate the engine speed. It is also controlled by the action of the governor. When the operator has set the throttle in the position to give the desired engine speed, the governor maintains this speed by means of its connection with the throttle, even though the load on the engine varies. (See p. 412.)

The carburetor diagram shown in Fig. 286 has been used to explain some of the basic principles of carburetor descriptions and is not a reproduction of any particular make of carburetor. All the descriptions below, however, are of tractor carburetors in general use.

Zenith Series 90

Path of Fuel and Air. The fuel enters at the top of the float chamber and passes through the filtering screen (Fig. 287*D*), which may easily be screwed out for cleaning. Then the fuel flows downward to the float chamber through the float valve (*R*), which is actuated by the hollow metal float (*F*).

There are two passages by which the fuel may flow from the float chamber to the jets. The size of the opening into the lower one of these two passages is determined by the main-jet regulator (*H*), which regulates the rate of flow to the main jet (*K*).

The flow through the other passage is regulated by the compensator (*L*), as the fuel flows through it into the compensating well (*W*), and thence up to the cap jet (*N*).

The main-jet regulator (*H*) and the compensator (*L*) are not manual adjustments but variable parts, furnished in several sizes by the manufacturer of the carburetor so that the

carburetor may be more closely adapted to the type of work it is to perform.

The tips of both the main jet and cap jet are located in the most constricted portion of the Venturi tube (X), which results in effective spraying and mixing. The air enters past the choke

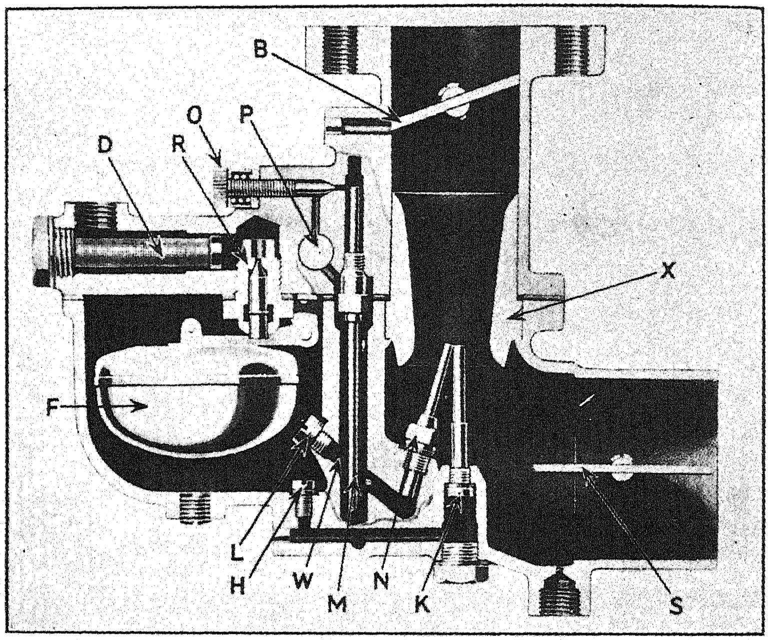


FIG. 287. Zenith (series 90) carburetor.

or air shutter (S), and sweeps upward past the jets and through the Venturi tube when the engine is running with open throttle. (For the passage of air and fuel at idling speed, see below.)

Action at Idling Speed. The compensating well (W) is a comparatively large cylindrical well drilled down into the metal body of the carburetor. This well is open to the air at the top through the air opening and passage (P). When the engine is stopped, the level of fuel in the compensating well is

the same as that in the float chamber. Likewise, the idling jet or tube (M) will be filled to the same level, for fuel from the compensating well may enter the lower end of this tube.

When the engine is idling, the throttle is practically closed; consequently there is very slight action at the jets (N and KO). A small passageway connects a point above the throttle to the top of the idling jet (M). On account of the high vacuum in the intake pipe, fuel is drawn up the idling jet and through this passage, thus entering the intake pipe above the closed throttle. Air is also mixed with this idling fuel supply. It enters at (P), passes over the point of the idling needle valve (O), and meets the fuel just at the tip of the idling jet.

Action with Open Throttle. As the throttle is slowly opened and the inrushing air passes the jets N and K, the amount of fuel delivered from these jets increases and the action of the idling jet decreases and soon stops entirely; the entire fuel supply coming from the jets N and K when the throttle is opened.

Automatic Proportioning. At low speeds, the air passing through the Venturi tube draws fuel out of both the compensating jet (N) and the main jet (K). Note that the most restricted portion of the Venturi tube (X) is directly opposite the top of the jets. At low speeds the compensating jet (N) will deliver a comparatively large amount of fuel or rich mixture since the compensating well (W) is almost full and the main jet will give a comparatively small amount of fuel or a lean mixture; but together they deliver the correct proportion of fuel into the air stream.

At high speeds, however, the flow out of the main jet (K) becomes richer because it is directly affected by the increased air velocity; but the flow from N becomes leaner owing to the fact that it is fed from L, which will permit only a certain rate of flow regardless of the speed of the engine. Consequently, air begins to enter the compensating well through the opening P, and mixes with the fuel flowing from L to the cap jet (N).

Thus, at high speeds, one jet gets leaner and the other richer, so that the mixture is correct at all times.

Manual Adjustments. The idling needle valve (*O*) is used for regulating the proportions at idling speed. Its effect is, of course, only noticeable when the engine is running with closed throttle. As this needle valve controls the supply of air entering the idling mixture, it is turned clockwise to enrich the mixture or counterclockwise to obtain a leaner mixture.

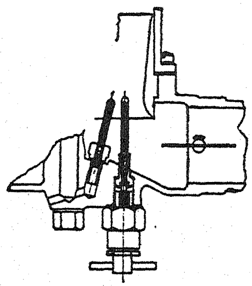


FIG. 288. Main-jet adjusting needle.

An adjusting needle for the main jet is not usually necessary but is furnished by the manufacturer if desired. It is screwed into the lower end of the main jet, as shown in Fig. 288. Turning this needle clockwise makes the mixture leaner; and, counterclockwise, richer. Directions for adjusting the Zenith are given on p. 416.

Acceleration

While the engine is idling the compensating well is nearly full of fuel, thus forming a reserve supply for acceleration.

With the throttle just "cracked open" in idling position there is a high vacuum above it on the manifold side, and atmospheric pressure below it. If the throttle is suddenly opened, there will be a rush of air to fill the vacuum and the reserve fuel in the compensating well will supply the necessary enrichment to meet this demand.

IHC UPDRAFT

The following description is adapted from the manufacturer's instruction book.[1]

This carburetor is a plain tube single venturi type having an air bleed well method of compensation (automatic proportioning).

[1] Courtesy of International Harvester Co.

The removable venturi (1) measures the volume of air which passes through the carburetor and creates a metering vacuum which acts on the discharge nozzle (3), the main jet (2), and the main air bleed (4). The main jet (2), often referred to as the *high-speed jet,* exerts its principal influence at the full-load speed. Fuel from the bowl is metered through the main jet and discharged in the air stream at the point of greatest suction in the

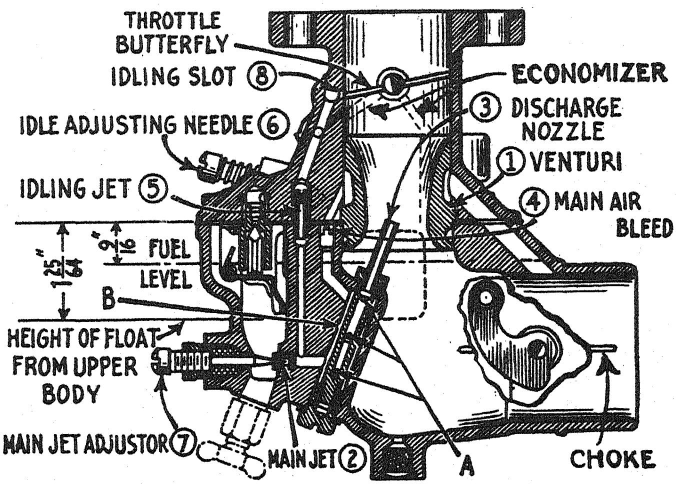


FIG. 289. IHC updraft carburetor.

Venturi. The main jet determines the maximum amount of fuel which may be obtained for full-load operation. The main-jet adjustment (7) reduces this amount as it is turned toward its seat.

The metering vacuum in the Venturi increases faster than the volume of air flowing through the Venturi. This would cause an increasing richer mixture of fuel to air as the engine speed increases to full load, unless this tendency is compensated for. To overcome this variation the solid fuel is bled out by air which is admitted from the space around the Venturi through the main air bleed (4) and into the space (B) surrounding the discharge jet (3). This air space is known as the *accelerating well.* The air enters the solid fuel from the main jet through the holes (A). The

well vent meters the amount of air which is admitted to fuel and allows a proportionately larger amount of air to be bled in as the suction on the discharge jet increases, thereby maintaining the fuel to air ratio fairly constant (automatic proportioning).

Idling System. The idling system consists of an idling jet (5) idle air-adjusting needle (6) and an idle slot (8). The idling jet (5) receives its fuel from the main jet and sprays it into the air, which is admitted from behind the Venturi (1). The amount of air is controlled by the idle air-adjusting needle (6).

The idling system controls the mixture ratio from slow idle to approximately fast idle. From fast idle to wide-open throttle or overload it has very little effect. At overload, or when the butterfly valve is in a wide-open position, the idle system reverses its flow and becomes an air bleed to the main fuel through the holes (*A*) in the discharge jet. The idling slot (8) is so arranged that the mixture is varied to suit engine requirements as the throttle butterfly is opened across or by it.

Economizer. At full power or wide-open throttle a certain mixture of fuel and air is required. Under part load a leaner mixture may be used. The tendency of the carburetor is to richen as the throttle is closed and as the idle system starts to become active. The 1¼ carburetor is arranged with a passageway leading from a space over the float chamber through a slot in the throttle shaft to the idle bypass channel (*D*). This slot is closed when the butterfly is in idle position, and opens as the throttle is opened. When the slot is open, the air bleed from the fuel bowl destroys any effect of the idle system richening the mixture. (Idling passage becomes inoperative above a fast idle.)

Intake Manifold

The intake manifold is located at the carburetor outlet (Fig. 283). The carburetor is attached to it by means of bolts or cap screws, and a gasket is used between the two parts to insure a tight connection. If air should leak in at this point the fuel mixture would become too lean, resulting in loss of power, irregular running of the engine, and backfiring through the carburetor.

The upper end of the intake manifold on four-cylinder

engines is usually divided into two branches, from each of which the fuel mixture may pass into either one of two cylinders. It is attached to the engine by studs which are screwed into the engine block. Copper gaskets lined with asbestos are used for this connection, for considerable heat is encountered. Air leaks have the same damaging effect at this point as between the carburetor and intake manifold.

The mixing of the fuel and air and the vaporization of the fuel are continued within the intake manifold, which is therefore designed with these factors in mind. The intake manifold is usually short and often completely surrounded by the exhaust manifold, so that the heat from the exhaust manifold will aid in vaporizing the fuel and prevent the vapor from condensing and gathering in drops or globules along the walls of the manifold.

Carburetion Heating Methods

With heavy fuels it is necessary to supply heat in some manner to insure complete vaporization. This may be accomplished in three ways:

1. Heating the liquid fuel.
2. Heating the air entering the carburetor.
3. Heating the mixture of fuel and air in the intake manifold.

The source of the heat thus employed is usually from the exhaust gases. This, of course, does not aid in starting the engine; hence gasoline is always necessary for starting purposes. All three of the above methods are in use, but the last is the most common.

In the first method, either the exhaust gas is directed around the float chamber of the carburetor or the liquid fuel is caused to flow through coils which are placed in the path of the exhaust gas. A shunt valve is usually provided by

which the exhaust gas may be diverted from the fuel should the operating conditions be such that it is not necessary.

The second method heats the incoming air by drawing it past the outer walls of a portion of the exhaust pipe. This method is not widely used on tractors.

The third method is shown in Fig. 283. The exhaust manifold, or in some cases a portion of it, is built around the intake manifold, so that the heat is applied to both the fuel vapor and air. An exhaust shunt valve is also provided in this type of construction, allowing for variation of the degree of heat as required. "Hot" and "Cold" positions of the valve are usually marked on the manifold.

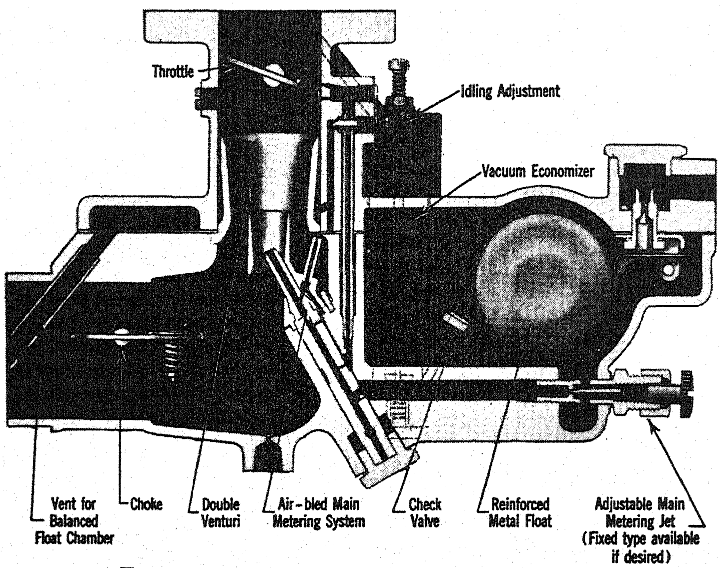


FIG. 290. Stromberg SF (side float) carburetor.

GOVERNOR
(Fig. 283)

The function of the governor is to regulate automatically the amount of fuel mixture admitted to the cylinders, thus con-

trolling the speed of the engine. It is usually driven by direct gear contact with the crank shaft or camshaft, so that the speed at which the governor weights revolve always has the same relation to the engine speed.

The weights are held together (in the closed position) by the springs when the engine is at rest. As the speed increases, the weights fly outward against the tension of the springs. This outward movement of the weights causes the sliding sleeve to press against the governor arm, which in turn is connected to the throttle. A sudden increase of load tends to make the engine run more slowly, but when the engine speed lessens the governor weights move closer together, and in so doing cause the governor arm to open the throttle wider and admit more fuel mixture to the cylinders. Thus the action of the governor maintains this rated speed even though the load on the engine varies.

The connections between the governor arm and the throttle are such that, when the engine is at rest and the governor weights are together, the throttle is in the wide-open position (unless closed by the hand-throttle lever).

The governor is designed and set at the factory to maintain a certain speed called the *rated speed*, at which the engine will operate efficiently and safely. A governor adjustment is usually provided, however, by which the speed may be varied slightly. Tightening the spring would increase the speed because it would cause the governor arm to act less readily in closing the throttle.

JOB 23

CARE OF FUEL AND CARBURETION SYSTEM

Procedure

1. Keep all gaskets between the carburetor and cylinders tightly fitted.

2. Keep fuel-pipe connections tight. Soap used on the threads of these connections will help to prevent leaks.

Threaded brass fittings called *compression couplings* are used for connections. (See Fig. 291.) These make it easy to get tight joints without swaging out the ends of the fuel pipes. The sleeve (*a*) is slipped over the end of the fuel pipe (*d*); the fuel pipe should then be seated firmly against the shoulder in the threaded coupling (*c*). When the nut (*a*) is tightened, it crimps the sleeve on the tube and swells it to make a tight joint. If leakage occurs at such a joint, cut the fuel pipe squarely and install a new sleeve.

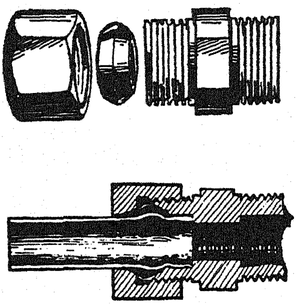


FIG. 291. Fuel-pipe connections.

3. Strain the fuel carefully when filling the tanks.

4. Drain the sediment bulb and float chamber of the carburetor often, to remove any water that has collected.

5. Be sure that the adjustment valves are secure. The vibration of the engine may cause these valves to work loose unless the binding nuts or retaining springs are tight.

6. Keep the air-vent holes in the fuel tanks open.

7. Clean the air strainer often. Keep it filled to proper level (if liquid is used). The lower portion of the air cleaner which contains oil may be easily removed. The old oil should be discarded and the container wiped clean and refilled with new engine oil to the indicated level.

The filter element should also be removed, washed with gasoline, and then moistened with oil. Air leakage anywhere between the air cleaner and the cylinders defeats the purpose of the air cleaner.

8. Store the tractor in a closed shed when it is not in use. This is necessary in the general care of the tractor, but it is particularly important in order that the fuel and carburetion system may be kept clean.

Carburetor Troubles

Any material change in the proportions of fuel vapor and air entering the cylinders will cause the engine to lose speed and power. Any of the troubles listed below may occur when the engine is running.

The following conditions make the mixture too "lean"—too much air in proportion to fuel vapor.

1. Fuel tank empty.
2. Needle valve closed too far.
3. Dirt or sediment in fuel tanks, fuel pipes, or carburetor.
4. Float valve out of adjustment so that it closes too quickly.
5. Air leaks between carburetor and cylinders.
6. Water in fuel.
7. Air vent in fuel tank closed.
8. Secondary air valve stuck open.

Whenever the mixture becomes too lean some of the indications listed below may be noticed.

1. Engine backfires, or pops back through the carburetor.
2. Engine misfires and runs unevenly.
3. Engine speed increases if choke is partly closed.
4. Engine speed increases if the operator opens the high-speed needle valve slightly.

The following list contains the usual causes of the mixture's becoming too rich—too much fuel vapor in proportion to air.

1. Needle valve open too far.
2. Float too heavy or punctured, letting too much fuel into the float chamber.
3. Float valve dirty or worn, and therefore not closing properly. This lets too much fuel into the float chamber.
4. Air passage closed or obstructed.
5. Choke-valve spring broken.
6. Secondary air valve stuck in closed position.

Whenever the mixture becomes too rich, some of the following indications may be noticed.

1. Black smoke from the exhaust pipe.
2. Smell of raw fuel at exhaust pipe.
3. Engine misfires and runs unevenly.
4. Spark-plug electrodes foul quickly.
5. Engine speed increases if the operator closes the needle valve slightly.

Adjusting the Carburetor

I—Zenith, Series 90 (Fig. 287)

1. Start the engine and warm it up to operating temperature.
2. Regulate idling-speed adjustment:

Set stop screw on throttle lever (Fig. 292) so that the engine will run sufficiently fast to keep it from stalling. Turn in or out on the idling needle valve until the engine hits evenly without rolling or skipping. Then back off on stop screw until desired engine speed is obtained. During the latter operation it sometimes happens that the idling needle valve can be opened a trifle, as the nearer the throttle is to the closed position, the greater the suction on the idling jet. The correct idling adjustment is usually found between one and three turns open of the idling needle valve. A good starting point is one and one-half turns from its seat.

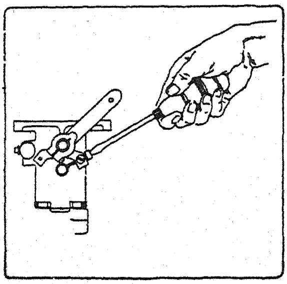


FIG. 292. Adjusting throttle stop screw to regulate idling speed.

3. A main-jet adjustment is shown in Fig. 288. This adjustment is not always furnished on tractor carburetors and, accordingly, the idling adjustment may be the only one necessary. If the main-jet adjustment is present, the following directions apply:[1]

[1] Zenith Detroit Corporation.

Retard the spark and open the throttle to approximately one-fourth open and turn the adjustment clockwise, shutting off the fuel until the R.P.M. of the engine drops because of lean mixture, then open the adjustment, by counting the notches, until the R.P.M. drops because of a rich mixture, then turn back half way between these two points to where the R.P.M. of the engine is the highest.

Care of the Zenith, Series 90, Carburetor

Due to the lack of moving parts affecting Zenith carburetor adjustment, about the only thing that can disturb its functioning is the presence of dirt and water. Accordingly, the carburetor should be cleaned periodically as this will insure uninterrupted operation. The fuel screen is removed by unscrewing the filter plug, as shown in Fig. 287*d*.

Fuel Level

The fuel level in the Series 90 carburetor is 5/8 in. below the top edge of the bowl. The weight of the float and the fitting and location of the fuel valve and seat are such as to maintain the fuel level in this position. These parts are interchangeable, so when necessary to change the fuel valve and seat assembly or the float assembly, this may be done without having to readjust the fuel level.

NOTE. Do not bend the float hinge to change the fuel level.

II—IHC Updraft (Fig. 289)

The proper mixture of fuel and air is controlled by the main-fuel adjustment and the idle-fuel adjustment. The throttle position to give the proper idling engine speed is controlled by the idle-throttle stop screw.

NOTE. The carburetor is correctly set when shipped from the factory. If the setting has been disturbed, the procedure below should be followed.

Before starting the engine, set the main-fuel adjusting screw 2½ to 3 turns open, and the idle-fuel adjusting screw 1 to 1½ turns open. Also set manifold heat-control valve in the "Hot" position.

Main-fuel Adjustment[1]

After starting, allow engine to run on gasoline about 20 minutes with governor control hand lever fully advanced and manifold heat-control valve in "Hot" position.

When heat indicator pointer shows in the green part of the dial, change over to operate on distillate or kerosene. After fuel bowl is full of distillate or kerosene, turn main fuel adjustment in until engine starts to miss or operate unsteadily, then unscrew until steady running is obtained. For satisfactory operation and power this adjustment should be checked under load.

For best operation and minimum dilution, keep adjustment as lean as possible. Screw in for lean and out for rich load mixture.

Idle-fuel Adjustment

Retard governor control hand lever to about one-fourth advance. Screw in idle throttle stop screw until the engine speed increases slightly. Now screw idle-fuel adjusting screw until engine runs steadily. Unscrew idle-throttle stop screw until the engine idles at desired speed, with governor control hand lever in full retard position. Idle adjusting screw turns in for rich and out for lean mixture.

Care of Carburetor

The fuel screen should be cleaned occasionally. Fuel screen is removed by unscrewing fuel line fitting. Flange nuts which hold the carburetor to the manifold should be checked periodically for tightness.

Note. Periodically check the screws fastening the fuel bowl to fuel-bowl cover and see that cover screws are kept tight to avoid any air leak past the fuel-bowl cover gasket.

[1] Material on this page is quoted from the International Harvester Co.

CHAPTER XIV

IGNITION SYSTEM

The ignition system provides a means of setting fire to the fuel mixture inside the cylinder. Electricity is used for this purpose because it is dependable and can be accurately controlled and timed.

Parts of the Ignition System

The electricity for ignition may be generated either by a battery or by a magneto.

Battery. A battery is a group of cells which generate electricity by the chemical action of certain elements within them. There are two kinds of battery cells in general use.

1. *Dry-cell Batteries.* Such batteries are called *dry* because the cells contain no liquid. They do not last long and must be thrown away when they are used up. They are the cheapest in first cost, but are not often used on tractor engines.

2. *Storage Batteries.* A battery of this type is quite large and heavy. It is made of two kinds of lead plates and is filled with dilute sulphuric acid. When a storage battery has run down it may be renewed. To do this, it is necessary to pass a current of electricity through the battery for several hours. This process is called *charging the battery.* Storage batteries cost more than dry-cell batteries but they last much longer.

Storage batteries are often used on tractor engines. They furnish light for night work and power for starting the engine, as well as electricity for ignition. When a storage battery is used, a generator is also required. It is constantly driven by the tractor engine, and produces an electric current which flows through the battery and keeps it charged.

Magneto (Fig. 267). The magneto is a small, compact machine, driven by the engine. It generates electricity whenever the engine is running. It is very dependable and, if given good care, will last as long as the engine to which it is attached.

The type of magneto now used on tractor engines generates an intermittent, high voltage current suited for ignition only; it cannot be used for lights; it generates current only when driven by the engine.

Ignition Wires. Copper wires carry the electricity from the magneto or battery to the cylinders of the engine. Copper is used because electricity flows through it very easily. These copper wires are wrapped with a covering of cotton, silk, or rubber. This covering is called *insulation*. It prevents the electricity from leaking out the wire. The wires which carry the current to the spark plugs are heavily insulated, for this current is under a very high electrical pressure and would easily break through a thin insulation.

Induction Coils. In engines with battery ignition, an "induction coil" is required between the magneto or battery and the spark plugs. It transforms the current from the battery into a current of much higher electrical voltage (pressure) before it goes to the spark plugs.

This process of induction or transformation of an electric current from a low to high voltage also takes place within tractor magnetos. Hence they are called *high-tension magnetos*.

Spark Plugs. The spark plug causes the electric current from the magneto or battery to make a spark. It is this spark that lights the fuel mixture. Each cylinder has one spark plug. The bottom part of the spark plug has two small wires called *electrodes*. Between these electrodes there is a small air space or gap. The electric current, because it is under high voltage (pressure), jumps across this gap, thus making a spark. Figure 301 shows a cross section of a spark plug.

MAGNETO CONSTRUCTION

The magneto is so named because one of its parts is a permanent magnet. There is a peculiar relationship between magnetism and electricity; either one can easily be made to produce the other. If magnetism is available, it can be made to produce electricity.

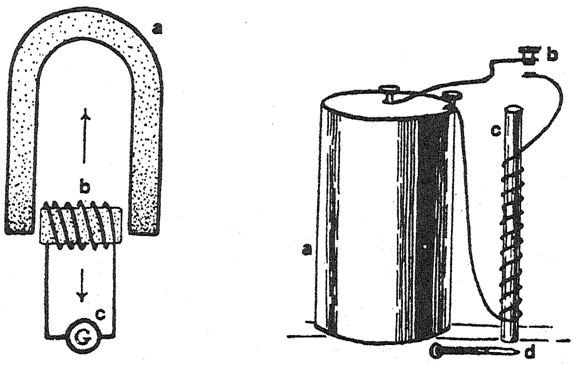


FIG. 293. *A*—Generating electricity from magnetism. *B*—Producing magnetism from electricity.

When the iron core with the coil is moved up or down, as shown by the arrow (Fig. 293), a current of electricity will be generated. This will be a very feeble current, but a delicate, electric-measuring instrument (*G*), connected between the ends of the coil of wire, will indicate its passage.

The strength of the current in this simple magneto depends upon three things.

1. Strength of the magnet.
2. Speed with which the core is moved.
3. Amount of wire in the coil.

If we have electricity available, it is easy to produce magnetism. Figure 293 shows a small dry battery cell. If several

turns of wire are wrapped around a soft-iron rod (*c*) and the two ends of the wire are connected to the battery as shown, the iron rod will be a magnet just as long as the switch (*b*) is closed. The bar will then attract the nail (*d*) to it. As soon as this switch is opened, the iron bar will lose its magnetism and the nail will drop.

The strength of the magnetism in the bar depends upon the following factors:

1. Strength of the electric current flowing around it.
2. Number of turns of wire wrapped around it.
3. Material in the bar itself. (Soft iron may be magnetized quickly and demagnetized quickly; hard steel will become magnetized slowly and lose magnetism slowly.)

Both principles described above are utilized in the construction of magnetos. The large, permament magnets on the outside of the magneto (Fig. 294) are used to generate a low-pressure current of electricity. This is called the *primary current*. This primary current flows through a coarse wire wrapped around a soft-iron core (Fig. 295). Whenever the primary current flows, the core is magnetized. Over the wire through which the primary current flows there is another winding consisting of many thousands of turns of very fine wire (hair size). In some magnetos there is as much as two miles of this fine wire. This is called the *secondary winding*.

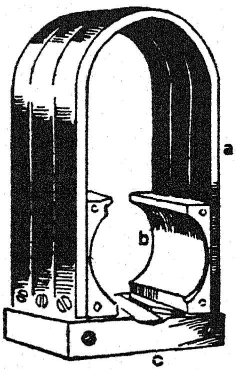


FIG. 294. Magnets, pole shoes, and base of a high-tension magneto.

As long as the current flows *steadily* through the primary circuit, there is no current in the fine wire of the secondary winding; but, when the primary current is *suddenly stopped* by opening its circuit (just as the flow of current was stopped by opening the switch shown in Fig. 293), the core upon which

both windings are wrapped loses its magnetism, and a very high-pressure current is induced in the secondary circuit.

The strength of current in the secondary circuit depends upon the following factors:

1. Number of turns of wire in the secondary winding.
2. Strength of magnetism in the core.
3. Quickness with which the core is demagnetized.

In all magnetos there is a circuit breaker in the primary circuit. This corresponds to the switch in Fig. 293. The circuit

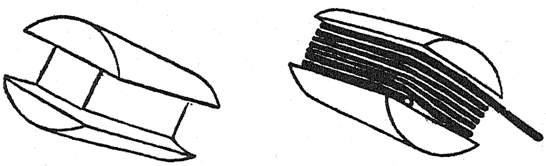


FIG. 295. Armature core and primary winding.

breaker stops the flow of the primary current by the opening of two contact points called *breaker points* (Fig. 296*c*). Whenever these points open, the primary current stops flowing, the core loses its magnetism, and a very high-pressure current springs up in the secondary winding.

One end of the secondary winding leads to the spark plug (Fig. 296*h*, *k*, *i* to *j*). This high-pressure current jumps across the electrodes of the plug and sets fire to the fuel mixture in the cylinder.

Magnets and Magneto Base (Fig. 294*a* and *c*). Magnetos may be made with one or more magnets. They are placed with like poles on the same side of the magneto. When like poles are placed together, the magnets will *not* attract but will repel each other. If the magnets should be put on the magneto so that the ends attracted each other, there would be no current generated.

The magneto base (*c*) is made of brass or other non-magnetic material. This causes all the magnetism to act through

the core, which revolves between the magnets. Magnetism cannot pass through the base.

Pole Shoes (Fig. 294*b*). The pole shoes concentrate the magnetism at the ends of the magnets. They are shaped to conform to the shape of the core which revolves between them.

Core (Fig. 295*a*). The core shows the soft-iron core on which the two windings are wrapped. This core revolves inside the pole shoes.

Primary Winding. The primary winding is first wound on the core as shown in Fig. 295*b*. It consists of fairly coarse, insulated copper wire. One end of this wire is bared and grounded to the metal core. The other end is connected to the breaker points as shown in Fig. 296*c*.

Secondary Winding (Fig. 296*h*). The secondary winding is wrapped over the primary. It consists of very fine, insulated copper wire. The insulation is scraped off one end, and the bare wire is grounded to the metal core, usually at the same point at which the primary winding is grounded. The secondary winding is wrapped around the core, over the primary wire. Many thousands of turns of secondary wire are wrapped on, and finally one end is brought out and connected to a brass ring called the *collector ring* (Fig. 296*k*).

Collector Brush (Fig. 296*i*). This is a small, stationary carbon brush that is pressed down against the collector ring. It picks up the electric current that comes from the secondary winding.

Distributor Arm (Fig. 296*b*). The collector brush carries the current to the distributor arm. This is a revolving arm, driven by the upper shaft in the magneto. As the distributor arm revolves, it comes into contact with the four segments (*a*) to which the spark-plug wires are attached. Thus it distributes the high-tension current to the different cylinders in proper order.

Breaker Points (Fig. 296*c*). Electricity is generated in the primary winding whenever the magneto begins to turn. This current flows from the winding out to the breaker points, as shown in the illustration. When these points are together, the current can flow across the points and back through the metal of the magneto to the point where the primary winding

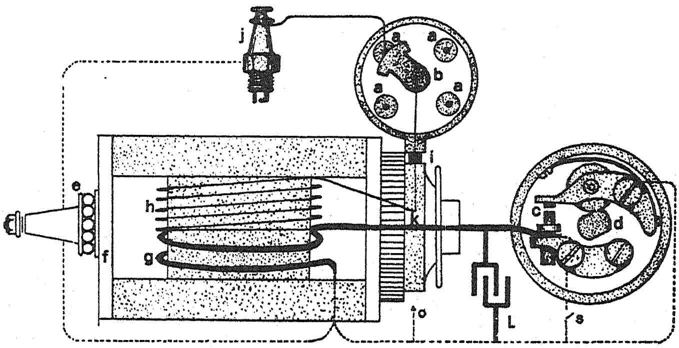


FIG. 296. Cross-sectional diagram of high-tension magneto.

is grounded. Whenever the current is flowing, it strongly magnetizes the core on which it is wound. At the instant the breaker points open, this current stops flowing and the core loses its magnetism. This quick change in the magnetic strength of the core generates or induces the current in the secondary winding.

Electric and magnetic action takes place so quickly that we may say all the following events occur at the same instant:

1. Breaker points open.
2. Current stops flowing in primary circuit.
3. Current springs up in secondary circuit.
4. Spark jumps between electrodes of the spark plug.

Complete Armature (Fig. 296). Non-magnetic disks are placed across the ends of the core. The core, with the windings and collector ring, is mounted on a steel shaft which is sup-

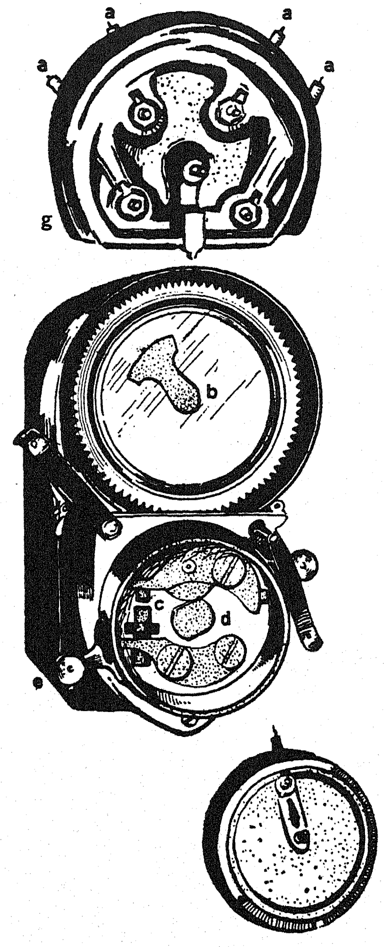


FIG. 297. Front view of magneto (distributor head and breaker-box cover removed). *a*—Distributor terminals. *b*—Distributor rotor. *c*—Breaker points. *d*—Breaker-point cam. *e*—Spark-lever connection. *f*—Breaker-box cover. *g*—Distributor plate or cap.

ported by ball bearings at both ends (*e*). This assembly of parts is called the *armature*.

Condenser (Fig. 296*L*). The condenser might be called an *electric sponge*. It is made up of alternate sheets of tinfoil and mica. It has the capacity to store up electricity for a short time. One side of the condenser is connected to the primary wire leading to the breaker points, and the other side is grounded as shown. The condenser prevents the breaker points from burning out, and also makes a quicker and more complete stoppage of the primary current.

Breaker-point Cam. One end of the armature shaft carries a cam. As the armature shaft revolves, the high point of the cam strikes the movable breaker point and forces the points apart (Fig. 296*d*). There are two high points on the cam shown; therefore, the points will be opened twice for each revolution of the armature.

Breaker-box Cover and Shorting Switch (Fig. 296*S*). The breaker points are enclosed by an insulated cover which

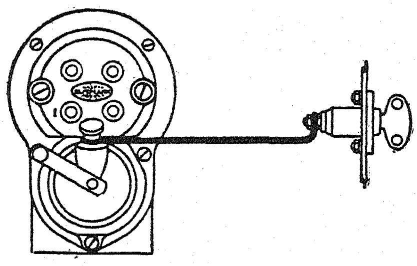


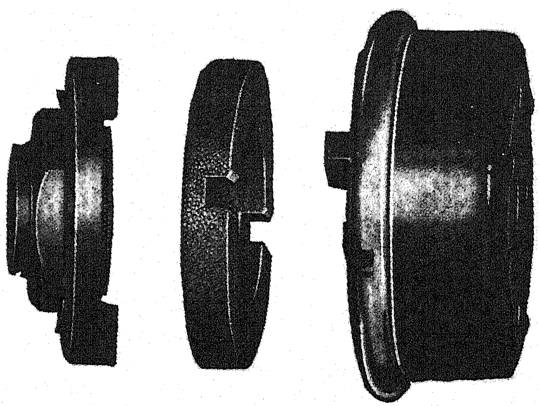
FIG. 298. Magneto shorting switch.

keeps them clean and dry. A flat, metal spring is attached to the breaker-box cover. The inner end of this spring is connected to the primary circuit of the magneto. The outer end of the metal spring is connected to a wire which leads to a grounded switch key near the steering wheel (Fig. 298). Closing the switch diverts the current from the breaker points and

grounds it. With the switch closed, there is no interruption of current in the primary circuit, and accordingly no current is induced in the secondary circuit and no sparks occur in the spark plugs. This switch is called a shorting switch and affords a convenient method of stopping the engine.

Some magnetos are designed so that the shorting switch is closed by means of the movable break-box housing. Moving this housing to the full retard position closes the switch and grounds the primary current.

Impulse-starter Coupling (Fig. 299). The magneto is driven by an auxiliary shaft, which is geared to the crank shaft of the engine.



A B C

FIG. 299. Parts of the impulse coupling. *A*—Driving member. *B*—Driving disk. *C*—Impulse member.

One of the factors affecting the strength of the spark is the speed at which the magneto armature revolves. If the armature were directly and rigidly connected to the magneto driving shaft, the spark would be weak when the engine is being cranked, as the armature would then be revolving slowly. To overcome this difficulty and to eliminate the need for "spinning" the engine, a special type of coupling called an *impulse-*

starter coupling is used between the armature shaft and the magneto driving shaft. It is essentially a spring coupling between the two. As the starting crank is turned, the armature is locked and remains stationary, but the magneto driving shaft revolves and compresses or winds up the coupling spring until at the proper time a release mechanism frees the armature and the spring tension "snaps" it forward at high speed.

When the engine attains a speed of about 150 revolutions per minute, the armature-locking mechanism is automatically thrown out of action by centrifugal force and the coupling merely forms a direct connection between the armature and the magneto drive shaft.

If the magneto is properly timed, the impulse coupling will always give a "retarded spark" (see p. 433). It is therefore a valuable safeguard when cranking a tractor.

Safety Gap (Fig. 296*o*). The voltage in the secondary circuit may become excessive if a spark-plug cable should come off while the engine is running or if the spark-plug electrodes are set too wide. To prevent damage to the secondary winding in such cases, a safety gap is provided. Here the high-tension current will be grounded whenever the resistance in its normal circuit is greater than the air resistance across the gap. The spacing at the safety gap is $\frac{5}{16}$ to $\frac{3}{8}$ inch.

The safety gap is made by bringing a grounded screw or metal projection near some non-insulated part of the secondary circuit. The spacing of the gap is so wide that the voltage required to pass a current across it is considerably greater than the normal voltage. Accordingly, the safety gap is inoperative except when an abnormally large resistance is encountered in the secondary circuit.

An "inductor" type of magneto, with a rotating magnet and stationary windings, is used in the design shown diagrammatically in Fig. 300. The magnetic field, set up by the rotating magnet, alternates through the coil bridge (core) and thus generates the primary current.

The primary current flows around and strongly magnetizes the coil bridge or core. When the primary current is inter-

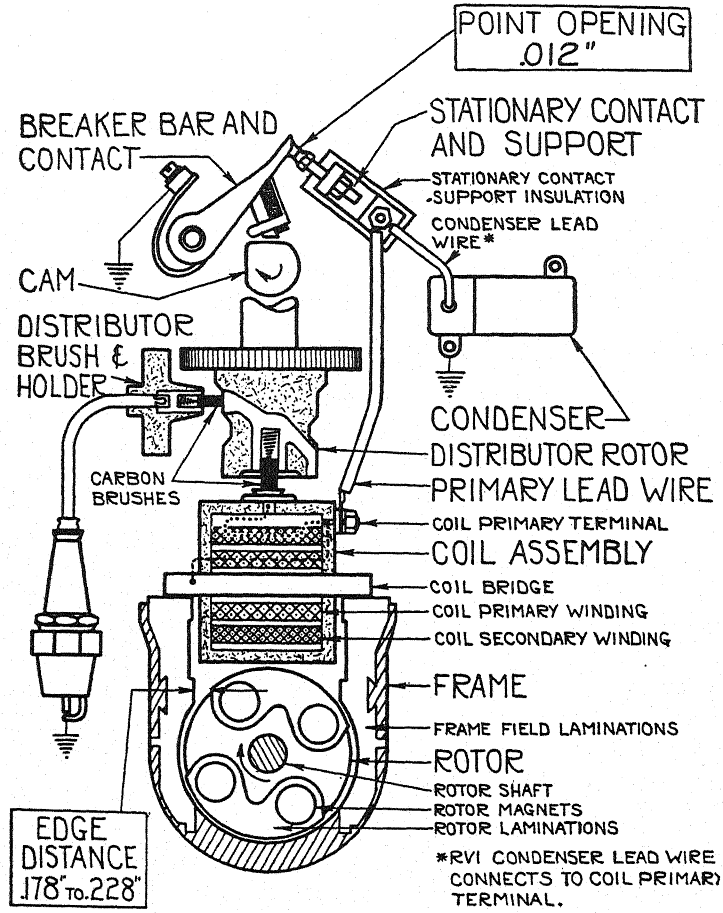


Fig. 300. Cross-sectional diagram of Fairbanks-Morse inductor-type magneto.

rupted by the opening of the contact points, the magnetism collapses through the secondary winding, thus generating the

high-tension current which is conducted to the spark plug by the distributor rotor and brushes.

Spark Plugs

Sizes and Threads. The size is determined by the outer diameter across the base of the spark-plug shell. The following sizes are used in various models of tractors.

½ inch, with standard pipe thread, tapered (requires no seat gasket)
⅞ inch (uses seat gasket)
10 millimeter (uses seat gasket)
14 millimeter (uses seat gasket)
18 millimeter (uses seat gasket)

Construction. A cross section of a spark plug is shown in Fig. 301. The base of the plug (*a*) is made of metal. It is threaded at the bottom, where it screws into the cylinder. The central portion (*d*) is made of an insulating material such as porcelain or mica. The center electrode (*c*) passes through the porcelain or mica and is thus insulated from the metallic base of the plug. The outer electrode (*b*) is directly connected to the base and thus grounds the electric circuit. The seat gasket (Fig. 307) is compressed when the spark plug is installed and makes a tight connection.

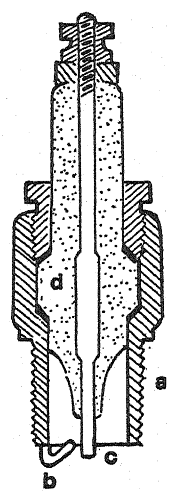


Fig. 301. Cross-section of spark plug.

Selecting Spark Plugs. The new tractor engine is furnished with spark plugs of the proper type, size, and thread. When replacement is necessary, identical plugs should be obtained. If a plug with the wrong thread is forced into the cylinder head, the threads there may be destroyed, necessitating expensive repairs.

Too short or too long a plug (Fig. 302) will also give trouble.

The bottom of the shell should be about even with the inside of the cylinder head. If the plug is too short it may foul quickly, as the spark occurs at a greater distance from the center of the combustible mixture, and exhaust gases may be trapped in the pocket thus formed. Such a plug is likely to remain too cool and will hasten carbon formation on the terminals.

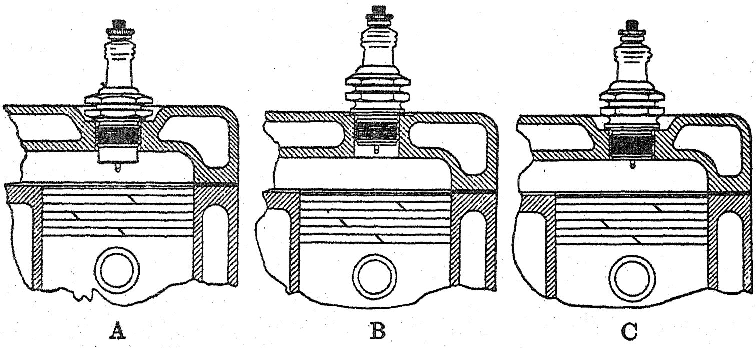


FIG. 302. Spark-plug lengths. *A*—Too long. *B*—Too short. *C*—Correct.

If the plug is too long, the points extend well into the combustion chamber and away from the water jacket. Such a plug tends to get too hot and may cause preignition.

Spark plugs vary not only in size, thread, length, and construction, but also in the heat-resisting characteristics of the insulator. Both electrodes are subjected to the heat of combustion of the burning fuel. The outer electrode transfers its heat directly to the shell of the spark plug, thence to the cylinder head and the cooling system. The center electrode, however, must pass off its heat through the tip of the insulator to the shell of the plug, as indicated in Fig. 303. The two spark plugs shown have heat-flow paths of different resistances, or it may be said that plug *A* will stay hotter than plug *B*. If the electrodes become too hot, preignition may result. If the electrodes are too cool, the carbon that forms on them will not

be burned off and fouling may result. For this reason, the tractor manufacturer selects a spark plug that is well adapted to the operating temperatures of the engine and, when replacement is necessary, it is important that identical plugs be used. In extreme cases, where fouling is encountered and all other causes for the trouble have been eliminated, a hotter type of

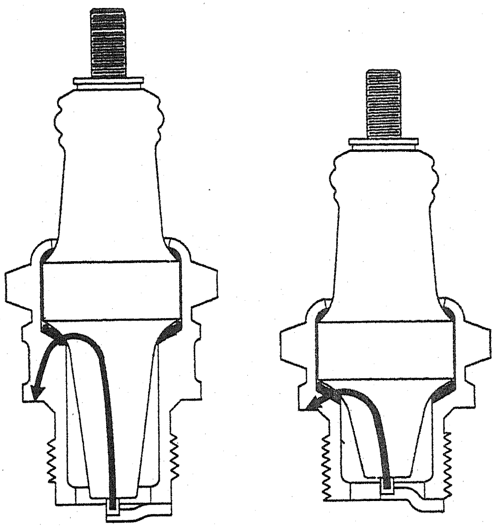


FIG. 303. Heat-flow path in spark plugs.

plug may be advisable; if preignition and rapid burning of the points is experienced, a cooler type, *B*, may be desirable.

Spark Advance and Retard. The meaning of the expressions *advanced spark* and *retarded spark* should be made clear by a study of Figs. 304 and 305. In the former, the spark occurs before the piston has completed the upward travel of the compression stroke. An advanced or early spark is required when the engine is running at full speed because it is necessary to have all the fuel mixture burning when the piston

starts downward on its power stroke. To accomplish this, when the engine is running fast, the spark must occur before the piston reaches top center, since it requires a definite time interval for all the fuel mixture to catch fire or, in other words,

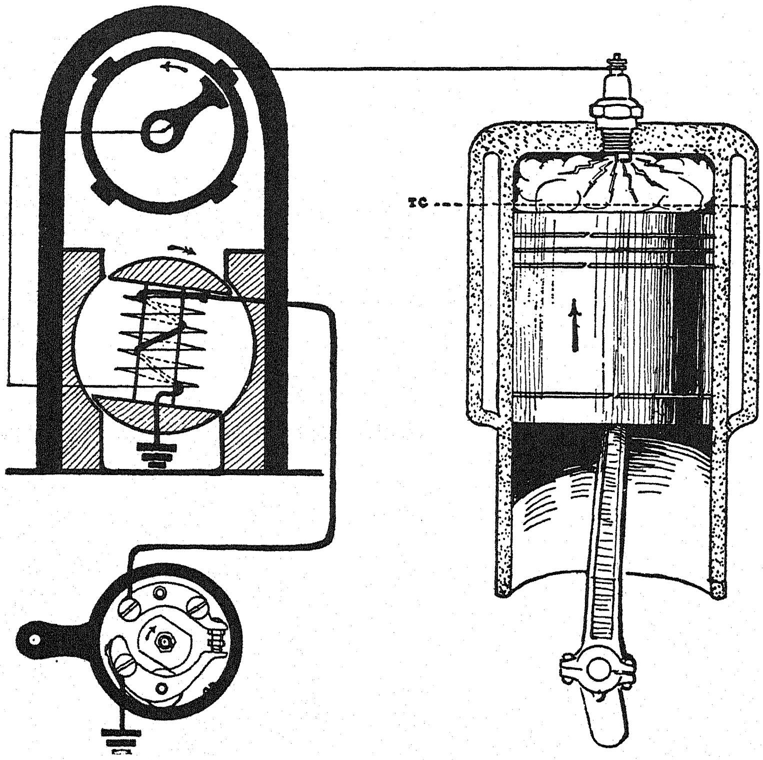


FIG. 304. Position of magneto parts and piston for advanced spark.

for the flame about the spark plug to be propagated to all parts of the combustion chamber. The amount the spark is advanced, or the distance before top center at which it should occur, depends upon the rate of piston travel, size of the combustion chamber, and other factors, but the one most likely to vary is the speed of the piston. Hence it is customary in

automobile engines requiring flexibility to have the spark advanced automatically by governor action, which gives the correct timing for any engine speed.

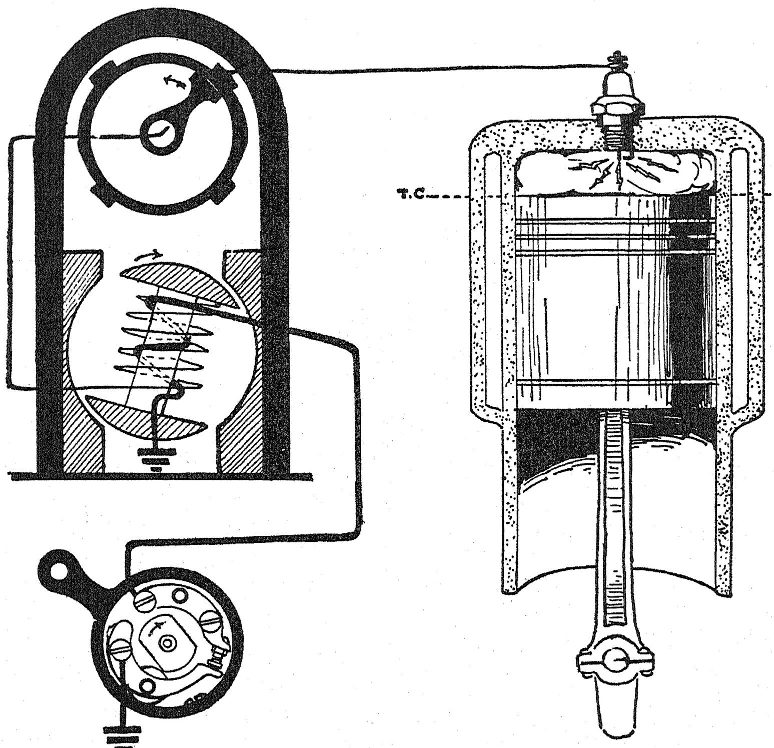


FIG. 305. Position of magneto parts and piston for retarded spark. Spark-timing lever is moved in the direction of rotation of the armature to retard the spark.

The speed of tractor engines, however, is usually held within small variations due to a governor's acting upon the throttle of the carburetor. Thus there is little need for automatic control of the spark advance, and either it is controlled manually with a small lever near the seat or the position of the timing

lever is "set" to give the proper advance for the rated engine speed. The second type of construction is referred to as a *set spark*. The breaker-box housing is securely locked in place and the spark lever is removed. In this construction, dependence is placed on the proper functioning of the impulse coupling to secure a retarded spark when starting.

A retarded spark, such as illustrated in Fig. 305, is necessary when the engine is cranked, for then the spark should not occur until the piston reaches, or passes, top center. With the spark thus delayed or retarded there is little probability of the engine's "kicking back."

The impulse-starter coupling, for magnetos, is always timed to give a retarded spark. This means safety when cranking the engine.

JOB 24

CLEANING AND ADJUSTING SPARK PLUGS

Procedure

1. Keep the exterior of the spark plugs clean and dry at all times. Accumulation of dirt, grease, oil, or moisture on the outside of the plug may cause misfiring.

2. Disconnect the spark-plug cables after marking them or taking other precautions to reconnect each to its proper cylinder.

3. Screw out the plug with a spark-plug wrench or other socket wrench that fits properly. Cracked porcelains or stripped hexagons on the shell are likely to result if the correct type of wrench is not used.

4. Separable or two-piece spark plugs may be disassembled for cleaning by unscrewing the bushing nut and taking out the insulator.

5. Wipe the insulator clean and dry with a cloth moistened in gasoline. Alcohol or metal polish will be helpful in loosening the hard carbon on the insulator and shell. A knife may be

used for scraping the carbon from the inner wall of the shell, but should not be used to scrape the insulator. Scraping the insulator with a knife may cause it to become porous. The electrodes should be cleaned with emery paper. The seat gaskets should also be inspected and cleaned if they are to be used again, but it is better to use new gaskets.

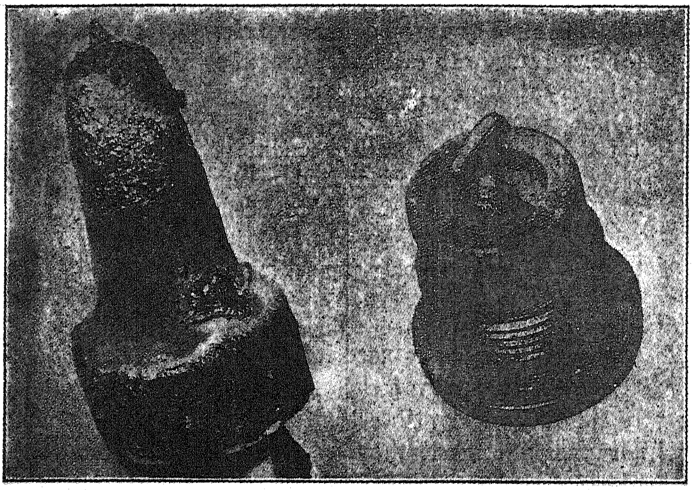


FIG. 306. Actual photograph showing accumulated carbon, mineral deposits, and firing points badly worn away.

When reassembling two-piece plugs be sure that both seat gaskets are in place and that the insulator is properly centered in the shell. Draw the gland nut down tight. Be careful in handling porcelain.

6. Spark plugs should be removed, cleaned, and adjusted at definite intervals. The distance between electrodes increases as the electrodes are used, because the firing points wear away. This condition is likely to cause hard starting.

Electrodes set too far apart, or points worn off so that the gap is too great, may cause missing under heavy loads or cause the plug to foul.

Electrodes set too close may cause missing under light loads or when idling, resulting in fouled plugs.

Fouled spark plugs become carbonized and short-circuit the plugs.

Nearly all spark plug sooting or fouling can be traced to one or more of the following causes:

(*a*) Using a plug of incorrect size, length or design.
(*b*) Operating at very low temperature.
(*c*) Long runs with carburetor choked or partially choked.
(*d*) Very rich carburetor mixture.
(*e*) Oil pumping.
(*f*) Cold weather operating conditions when engine is run only for short periods and never attains an operating temperature high enough to burn oil or soot before it carbonizes.
(*g*) Improper spark plug gap setting.[1]

Cracked Insulation

The porcelain insulators used in spark plugs are brittle and may become cracked by careless handling or through accidentally striking them with a tool. If the porcelain is cracked, the high-tension current may be diverted from the central electrode, through the crack to the outer shell, or it may be that the cracked insulation will disturb the position of the central electrode, thus changing the gap at the firing points. Either result may cause the cylinder to misfire and the plug to foul.

Use of Incorrect Type of Plug (See p. 431)

Spark plugs face three problems—fouling, preignition, and fast wearing away of the electrodes.

Fouling is caused by the insulator remaining too cool and evidences itself through missing of the engine.

Preignition is the result of the plugs becoming red hot and firing the mixture early, causing pinging and a sharp decrease in the engine's power.

[1] Electric Auto-Lite Co.

The fast wearing away of electrodes results from the plugs operating at too high a temperature.

Either fouling, preignition or rapid wearing away of the electrodes can be minimized, and often overcome, by making certain of having the correct plug.[1]

Installing Spark Plugs (Fig. 307)

1. Set the gap according to manufacturer's instructions. Measure

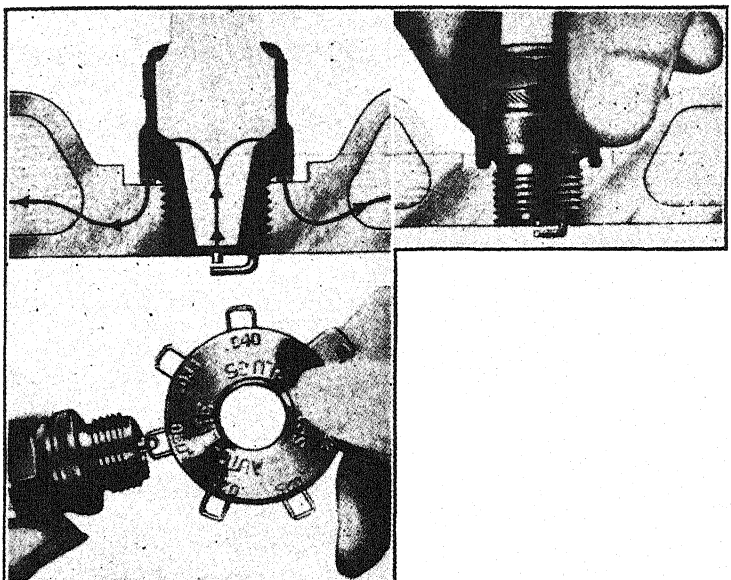


FIG. 307. Installing and adjusting spark plugs.

the gap with a spark-plug gauge. Adjust the gap by bending the outer electrode, do not bend the center electrode.

2. Clean the spark-plug seat in the cylinder head. Use new seat gaskets. Screw the spark plug into the cylinder by hand as far as it will go.

[1] A. C. Spark Plug Co.

3. Carefully fit a socket of the proper size over the plug, and pull on the handle very lightly until you feel contact with the seat gasket. Slowly increase the pull on the handle (you will feel the seat gasket compressing) until the resistance to your pull suddenly becomes very great, indicating that the seat gasket has been fully compressed.

The proper tightening of spark plugs is the most important item of all, as 50 per cent of the troubles due to overheated spark plugs are caused by the plugs' being too loose in the cylinder head. Referring to *C*, it is obvious that if a spark plug is not tightened sufficiently to compress the seat gasket fully, there will not be adequate contact between the shell and the cylinder head. This would interrupt the flow of heat from the spark plug to the water jacket and result in overheating of the spark plug, preignition, burning of insulator and electrodes, blow-by, etc.

The smaller the plug the less pull is required to compress the seat gasket.[1]

JOB 25

ADJUSTING, CLEANING, AND LUBRICATING THE MAGNETO

Procedure

1. When the distributor cover is removed by taking out the screws or unfastening the latch which holds it in place, the revolving distributor arm and the terminal brushes or segments are accessible. These should be wiped clean with cheesecloth or with other lintless cloth moistened with gasoline. Waste should not be used, and the parts should never be scraped with a knife, sandpaper, or emery paper. The carbon coating which collects on these parts may be hard, but it can be removed by washing if the operator is patient. If you use carbon brushes as distributor terminals, see that the brushes

[1] Electric Auto-Lite Co.

are not stuck but work freely in their guides against the tension springs.

After these parts have been washed carefully, they should be allowed to dry before the magneto is used.

2. While the distributor plate is off, the insulation and connections of the spark-plug cables should be examined carefully. Chafed or burned parts in the insulation should be carefully taped or the entire cable replaced. Provision is made at the distributor plate on all magnetos for securely holding and locking the cables in contact with the distributor terminals. The method used should be carefully noted if it is necessary to replace a cable. When spark-plug cables are replaced, they should be held away from the metal of the engine by the conduits or guides provided.

3. In some shuttle-type magnetos, the collector brush is removed with the distributor plate, which also exposes the collector ring. The collector ring should be cleaned in the same manner as the distributor, but caution should be taken to have the primary circuit grounded; otherwise, a spark may occur when the armature is revolved and the gasoline with which the collector ring is washed may catch fire.

4. The breaker points (platinum or tungsten) should be carefully inspected to determine:

(*a*) That the points are bright, dry, and clean (oil should never be allowed to collect on them).

(*b*) That they meet squarely and make good contact when closed.

(*c*) That the correct gap or air space exists between, at the point of maximum opening.

Remove the dust cap and wipe the interior of the breaker mechanism and points clean, with a lintless cloth. Crank the engine until the breaker points are open to the maximum and then examine the contact surfaces. They should show a full, square contact. If worn off unevenly, or pitted, file them with

a fine jeweler's file or contact-point file. (See Fig. 308.) Small oilstones designed for breaker points may also be obtained. These are best for use on tungsten points. In order to keep the points level when dressing them down, insert the file or stone between the points and dress both at once (the spring tension will serve to hold them against the file). Wipe off all filings. Dress down platinum points with jeweler's file and tungsten points with fine oilstone.

Adjust the points to the correct distance after cleaning and dressing. Crank the engine until the breaker points are opened

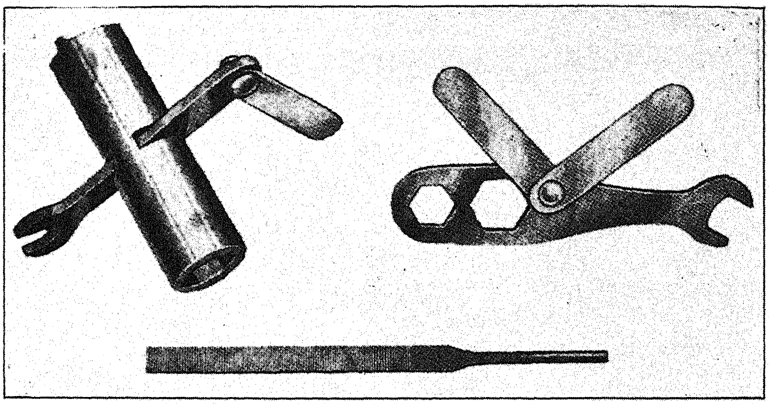


FIG. 308. Magneto wrenches, gauges, and breaker-point file.

to their widest position. If the action of the impulse starter makes it difficult to stop the magneto in this position, turn the engine backwards by pulling on the fan belt or belt pulley.

Loosen the locknut on the stationary breaker point and screw it in or out until the proper gap is obtained, using magneto wrenches such as those shown in Fig. 308. Secure the adjustment by tightening the locknut. The gap may be measured with a thickness gauge or with the gauge provided on the magneto wrench furnished by the manufacturer. It is measured by inserting the gauge between the points when they are

opened to their maximum. The exact setting may be obtained from the manufacturer's instruction book. An average setting for magneto breaker points is 0.015 inch.

5. The magneto should be lubricated carefully with light, non-gumming oil. Much magneto trouble is caused by over-lubrication. If oil is allowed to gather on the breaker points,

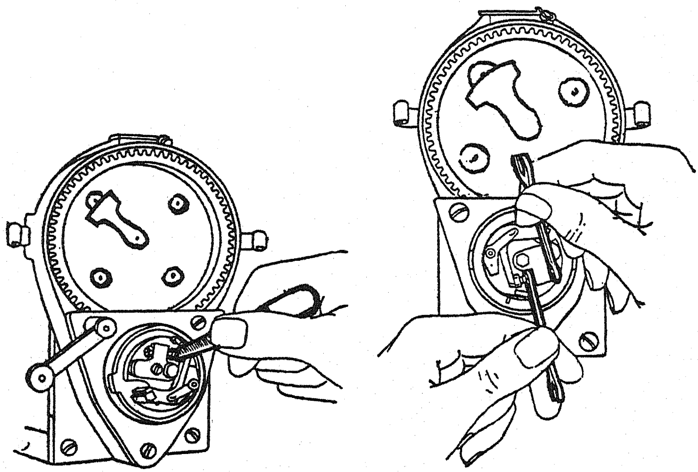


FIG. 309. Adjusting and measuring the breaker-point opening.

it is particularly troublesome; hence, the breaker mechanism on many magnetos is designed to operate without lubrication. Where oil holes are provided for the lubrication of the armature-shaft and distributor-shaft bearings, oil should be applied sparingly (two or three drops once a week are sufficient). Impulse starters, as a rule, do not require lubrication, but should be washed out occasionally with kerosene and then treated with a light oil to insure free action.

In some tractor magnetos an oil reservoir is provided which, if kept properly filled, takes care of the lubrication of all magneto parts. Others have bearings which require no lubrication.

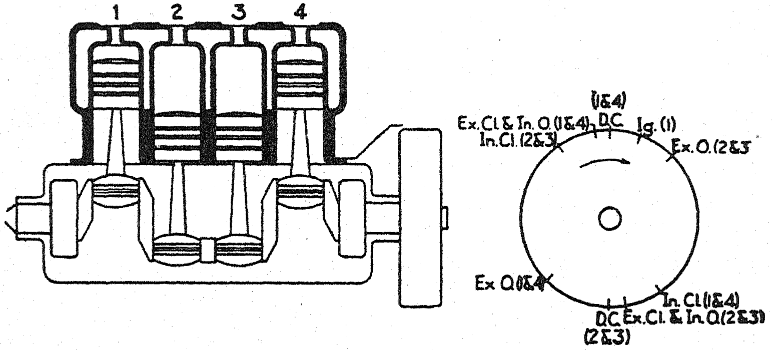
JOB 26

TIMING THE MAGNETO TO THE ENGINE

(Magneto Has Been Removed)

Procedure

1. Find the firing order. The magneto must be "timed" or coupled to the engine so that the breaker-point opening will have a definite and exact relationship to the piston position, or, in other words, the magneto must deliver a spark to each



N. Y. State College of Agriculture

FIG. 310. Timing marks on flywheel and reference point or "witness" mark on engine.

cylinder at the time when the piston in that cylinder is in the correct firing position.

2. Get piston 1 in firing position. This position will vary according to the type of magneto, namely, whether it has a variable spark or a "set spark," or whether it is to be timed with the impulse-starter coupling in operation. Timing marks (Fig. 310) are usually stamped on the flywheel for convenience and accuracy in positioning piston 1. The ignition time marks usually are placed so that when they coincide the piston is in the advanced spark position as shown in Fig. 304. If they are present it is only necessary to revolve the flywheel until the ignition mark referring to piston 1 lines up with the reference

point. It should be kept in mind, however, that these marks will line up once for each revolution of the flywheel, and it is only every other revolution that the marks have reference to the firing point of piston 1. If no timing marks are provided get piston 1 on top center at the end of compression stroke. If the flywheel is not marked, the piston should be brought to top center, as described above, and then the engine should be turned backwards until the piston has descended 1/8 inch. (Approximate method.)

3. Retard the spark. With variable spark magnetos, set the spark lever in retard position by moving the breaker-box housing as far as it will go in the same direction that the armature shaft revolves. For set-spark magnetos this step may be disregarded, and piston 1 should be 1/8 inch or about 20 degrees before top center. (See manufacturer's instruction book.)

4. Have breaker points just opening. Remove the breaker-box cover to expose the breaker points, and turn the magneto armature in the proper direction until the points begin to separate. The impulse starter can be prevented from operating by turning the armature first backwards slightly and then forward to the desired position.

5. Connect the magneto to the drive shaft. The magneto is now in position to deliver a spark, and cylinder 1 is in the proper position to receive it. The projections and recesses forming the various parts of the coupling (Fig. 299) should now be in line or very nearly in line.

To tighten the coupling the magneto is pushed forward until the tongues of the driving member and the impulse member are fully entered into the grooves of the floating disk; the magneto is then securely bolted to the supporting bracket.

The coupling is adjustable, making possible a very accurate control of the timing. Close adjustment is made possible by the construction of the driving member.

6. Connect spark-plug cables. Remove the distributor cover plate and note which terminal is in contact with the distributor

arm or rotor. Connect a cable from this terminal to spark plug 1.

Connect cables from the remaining distributor terminals to the spark plugs, according to the firing order, keeping in mind the direction of rotation of the distributor arm (usually opposite to the direction of armature rotation).

Tractor Electric System

A complete electric system, including battery, generator, starting motor, and lights is now available for most farm tractors. Such systems are similar in many respects to the system used on automobiles.

The wiring diagram shown in Fig. 311 shows the relation of the various parts. This system includes four circuits.

1. *Generator Circuit.* (*a*) The field circuit of the generator is grounded by a resistance switch, placed near the tractor seat. It is used to regulate the charging rate by inserting more or less electric resistance in the field current. Usually the charging rate for a tractor may be much lower than for a car.

(*b*) The output circuit of the generator connects through the cutout to the lower terminal on the ammeter, through the ammeter to the upper terminal of the starter switch, then to the negative terminal of the battery and through the battery to the ground. Because the positive terminal of the generator is grounded in this system, the current flows from the generator through the ground to the grounded (plus) terminal of the battery and from the battery through the circuit, back to the generator.

2. *Starting Motor Circuit.* This connects through the battery to the ground; through the ground to the grounded starter brushes; from the starting motor to the starter switch; across the starter switch (when closed) to the battery. The starting motor draws a heavy current, much too heavy to be registered on the small ammeter. Hence, the starting motor circuit does not pass through the ammeter, the only one of the 4 circuits which does not.

3. *Ignition Circuit.* (*a*) The primary ignition circuit is as

follows: battery to the ammeter; across the ammeter to the ignition switch; across the ignition switch (when closed) to the primary winding of the coil; from the primary of the coil to the breaker points; through the breaker points (when closed) to the ground and return through ground to battery. The actual direction of flow is in the reverse direction.

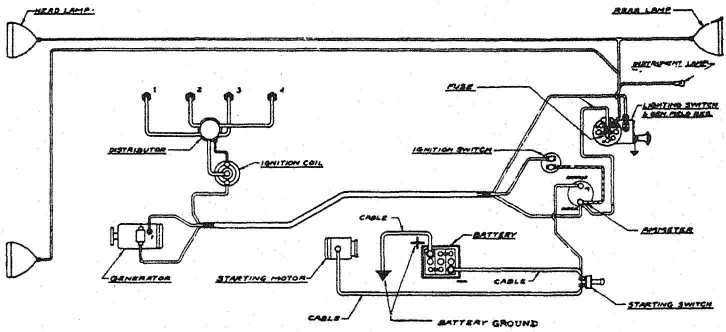


Fig. 311. Complete electric system for a farm tractor.

(*b*) The secondary circuit is as follows: secondary winding of the coil, to the center of the distributor cap and distributor rotor; through the rotor to distributor terminals; through cables to spark plugs; across spark-plug terminals to ground.

4. *Light Circuit.* The light circuit is from battery to the live side of the starter switch; to the ammeter; across the ammeter to the light switch; across the light-switch contacts (when closed) to the light-bulb filaments to the ground; return through the ground to the battery (current flow is actually in the opposite direction).

The cutout mounted on the generator serves as a one-way electric valve. It permits current to flow from the generator to the battery (a charging current) but prevents the current flow from the battery to the generator (a discharging current).

The breaker points, primary and secondary windings, condenser, and distributor have the same function as in the magneto.

CHAPTER XV

COOLING SYSTEMS

The tractor engine is a mechanism for transforming heat into work or mechanical energy. But no engine can successfully change all the heat of the fuel it burns into useful power. A large percentage is lost, and some is purposely carried away in order that the pistons and cylinder walls may be properly lubricated. If the high temperature existing in the combustion chamber at the beginning of the power stroke were not reduced, the engine would soon cease to function; lubrication would be impossible; the combustion-chamber surfaces and spark-plug terminals would become red hot; pistons would expand and seize on the cylinder walls.

The ignition temperature is lowered by the action of the cooling system, and also by the pressure within the cylinder when it falls rapidly as the power stroke is completed. Then the hot exhaust gas is driven out and a fresh charge of comparatively cool fuel mixture is drawn in.

The purpose of the cooling system is to maintain engine temperatures which will permit proper lubrication and thorough combustion of the fuel.

If the cooling system carries off too much heat, the engine "runs cold"; combustion within the cylinders is incomplete; fuel is wasted; the oil becomes diluted; and the efficiency of the engine is greatly lowered. On the other hand, if the cooling system does not carry away enough heat, the engine "runs hot" or overheats. This condition also brings serious troubles. However, adjustments are provided for regulating the action of the cooling system in order that the operator may maintain a suitable temperature, with the water in the cooling system just below the boiling point.

The parts most directly affected by the heat of combustion

are the cylinder walls, cylinder head, spark plugs, valves, piston, piston rings, and wrist pin. The cooling system is designed

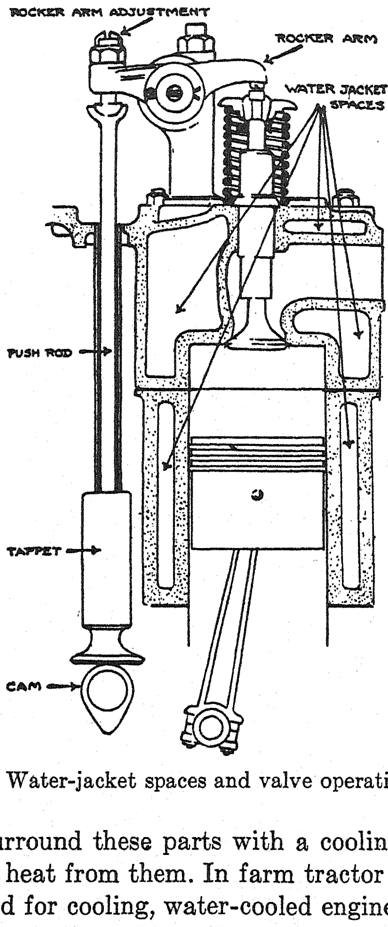


FIG. 312. Water-jacket spaces and valve operating parts.

to jacket or surround these parts with a cooling medium and to conduct the heat from them. In farm tractor engines, water and oil are used for cooling, water-cooled engines being by far the more commonly used. Air-cooling systems are used in some of the smaller models of garden tractors.

CONSTRUCTION OF WATER-COOLING SYSTEM

Water Jacket (Fig. 312). The upper portion of the cylinders, the cylinder head, valves, the base of the spark

plugs, in other words all parts that come in contact with the intense heat set up in the combustion chamber, are surrounded by a jacket or space through which the cooling water circulates.

Water jackets are designed to allow free circulation of the water; all pockets and projecting parts are eliminated within them. The jacket does not always extend the full length of

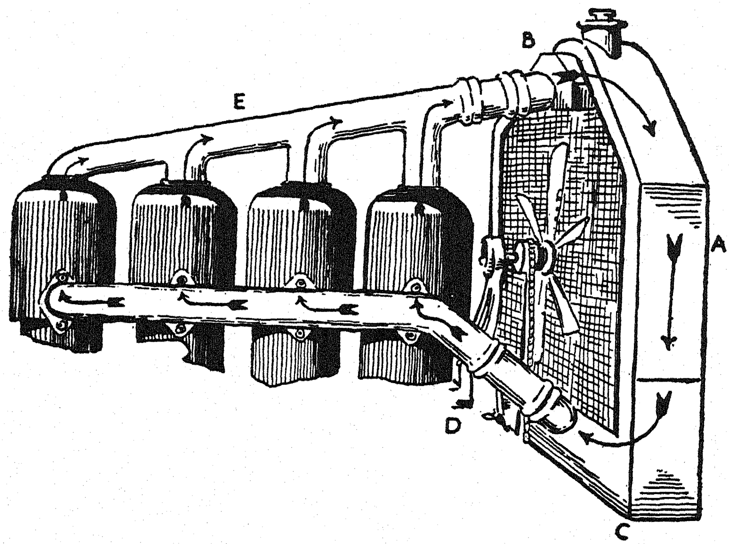


FIG. 313. Natural flow of water through a thermosiphon cooling system.

the cylinder because only the upper portion is subjected to great heat. It is customary to provide one or more drain cocks at the lowest point, in order that all water may be drained off during cold weather. It is necessary that all the parts above mentioned should be properly cooled; hence, the placement of the valves, spark plugs, etc., with relation to the water jacket, is a matter of great importance in engine design.

The water enters the jacket through the water-inlet pipe (Fig. 313), and, because of the heat absorbed from the combustion chamber, it rises and flows out the outlet at the top

of the water jacket (*E*) to the radiator. Water leaves the jacket at the highest point, eliminating the possibility of steam's being trapped within the circulating system.

Radiator. The function of the radiator is to pass off the heat absorbed by the water in its passage through the water jacket. The principle underlying radiator construction concerns bringing the heated water into contact with a large area of surface metal. The single stream of water flowing from the water jacket to the top of the radiator is there broken up into a large number of small streams which pass through metal tubes of high heat-conducting ability. The various parts of a typical tractor radiator are shown in Fig. 314.

1. *Upper Tank.* The upper tank receives the hot water from the jacket and distributes it to the vertical tubes of the core. It makes possible an even distribution of water, as the relation of the inlet to the upper tank and the combined area of the tubes is such that all the tubes function equally.

2. *Radiating Element or Core.* The water is exposed to a large cooling or radiating area as it passes from the upper to the lower tank. The radiating element connecting the two tanks is composed of a large number of copper or brass tubes. The tubular construction is strong and rugged, and is widely used in tractor radiators.

The cooling effect of the tubes is multiplied by the use of metal fins which make contact with the tubes and conduct the heat from them. They greatly increase the radiating surface and cause more rapid cooling.

The tubes are fastened to the top and bottom header either by packing nuts or by soldering. The complete assembly of tubes, fins, and top and bottom header is called the *radiator core*. The sides of the core are enclosed, and the whole assembly is strengthened by the side members or columns.

3. *Lower Radiator Tank.* The lower tank collects the water that has passed downward through the tubes and connects with

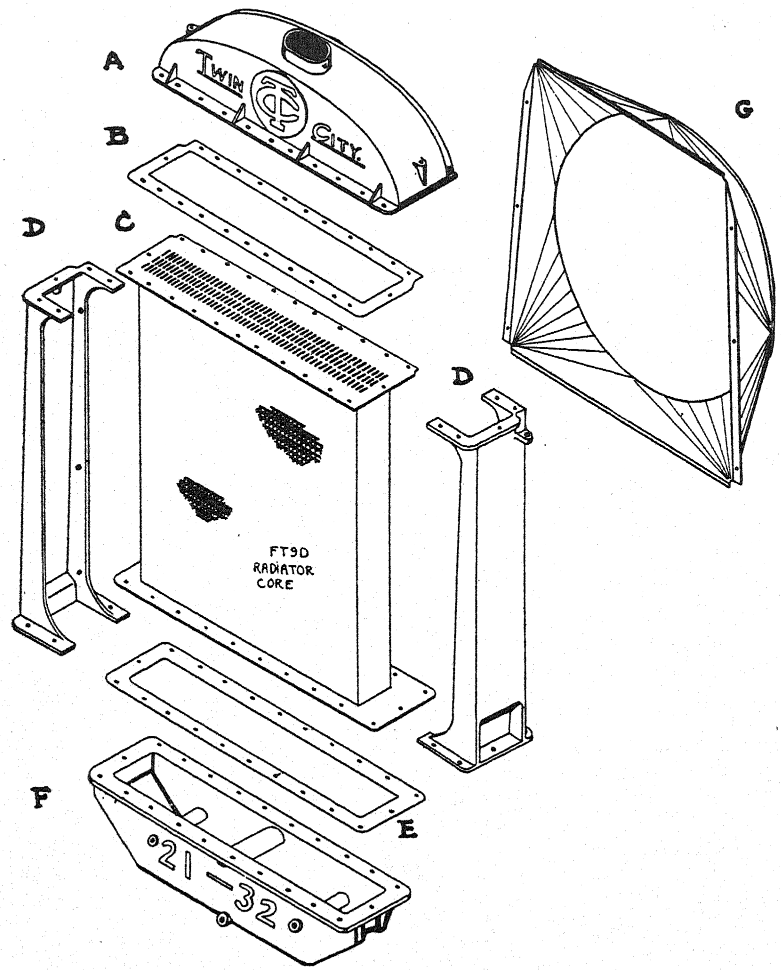


FIG. 314. Parts of the radiator. *A*—Upper tank. *B*—Gasket. *C*—Core. *D*—Side columns. *E*—Gasket. *F*—Lower tank. *G*—Fan shroud.

the outlet pipe through which the water returns to the water jacket. It is usually bolted to the bottom of the radiator core, a tight connection being made by the use of a suitable gasket.

Fan. Radiation of the heat from the tubes and fins of the radiator core is further increased by the fan which is placed directly behind the core of the radiator. The fan is usually shrouded (Fig. 314*G*) to increase the velocity of air which it draws through the core. It revolves at one and one-half to two times engine speed; hence it is carried on anti-friction bearings of the ball or roller type and adequate provision is made for lubrication. It is driven either by a belt or gears from the crank shaft.

Because of the fan's high speed, fan blades are sometimes broken or loosened if the engine is started with the throttle wide open. In some tractors, particularly those with large, heavy fans, the possibility of this trouble is lessened by means of friction members in the fan-driving mechanism which permit the fan to slip in starting.

Water-circulating Methods. The simplest means of causing circulation of the cooling water is that known as the *thermosiphon system.* As the water in the jacket about the cylinders is heated, it rises and flows to the upper radiator tank, being replaced by cooler water from the lower radiator tank, as indicated by the arrows in Fig. 313.

The most common method in tractor engines is *forced circulation.* In this method a pump is used. This provides a more positive and rapid circulation; moreover, obstructions in the cooling system are less likely to interfere with circulation.

In the centrifugal pump shown in Fig. 315, the water enters near the center. It is thrown outward by the revolving blades or arms of the impeller and is discharged at the outlet placed in the outer portion of the pump body.

Water pumps may be driven through a gear contact with the engine, frequently the same shaft driving both the water pump and magneto. In other designs, the pump is driven by

the fan belt. The shaft which drives the impeller of the pump must extend into or pass clear through the pump body. To prevent leakage, packing glands may be provided where the shaft enters the pump body. This space may be filled with packing, which is compressed by means of a packing nut so

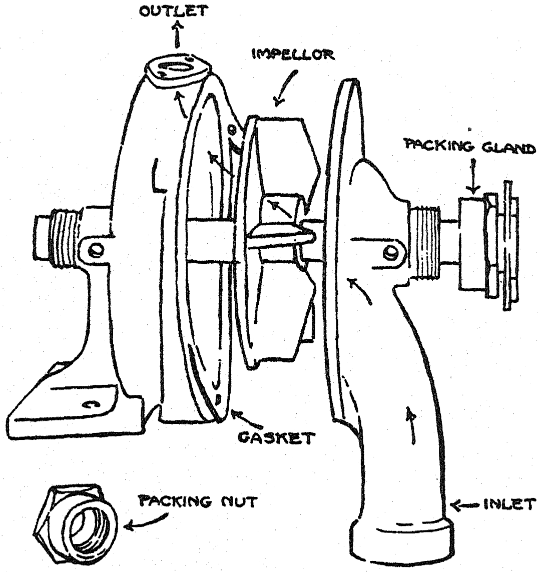


FIG. 315. Centrifugal water pump.

that the water cannot leak out along the shaft. More recent designs of pumps eliminate the need for packing.

Control of Cooling-water Temperature. Some means is desirable for controlling the temperature of the cooling water. A certain system which cools the engine satisfactorily on a hot summer day may cause overcooling on an intensely cold day. Proper operating temperature should be maintained at all times. Either a cold running engine or an overheated engine may cause serious troubles.

Cooling systems, as a rule, are designed to give satisfactory

cooling under the most severe conditions, that is, in the hottest weather and when the engine is operating under heavy loads. Accordingly, because of the size and capacity of the radiator, fan, pump, etc., the engine would reach its operating temperature or would "warm up" slowly unless some means were provided for lessening the cooling action when desired. Two methods are used in tractor engines, of which one stops the circulation of water through the radiator and the other cuts down the amount of air passing through the radiator.

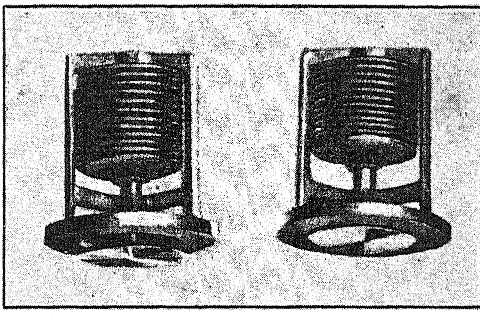


FIG. 316. Thermostatic valve for cooling system.

The first is accomplished by a thermostatic valve (Fig. 316) which is controlled automatically by the temperature of the water in the water jacket. When this is below approximately 160° F., the valve is closed and the water cannot pass out of the water jacket to the upper radiator tank. It flows through a bypass and is circulated again around the water jacket, or, in other words, the thermostat cuts the radiator out of the circulating system when the water is cool. When the temperature of the water increases to more than 160° F., the thermostat valve opens and the water circulates through the radiator.

With the thermostat closed, and the flow through the radiator cut off, the temperature of the water in the jacket rises quickly, or the engine warms up quickly. If the water temperature drops below 160° F., during operation, the thermostat valve

closes and the radiator is cut out of the circuit. Thermostat valves are entirely automatic in action and are not subject to adjustment by the operator.

The second method, which is the more commonly used, is that of lessening the air flow through the radiator. This is accomplished by means of a radiator curtain (Fig. 317), which

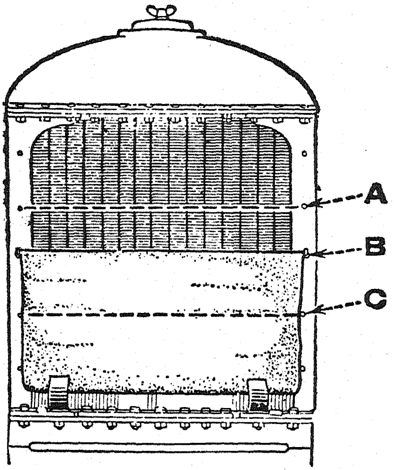


Fig. 317. Adjustable radiator curtain. *A*—Cold-weather position. *B*—Cool-weather position. *C*—Non-freezing or early morning position.

may be raised by the operator so that air is prevented from passing through a portion of the radiator. It should be used, particularly in cold weather, to cause the engine to warm up quickly and to maintain correct operating temperature.

JOB 27

CARE AND ADJUSTMENT OF THE COOLING SYSTEM

Procedure

Radiator and Water Jackets

1. Use only clean soft water or clean rainwater in the cooling system. Hard water contains minerals in solution which,

when subjected to heat, are set free and form a scale or coating on the inside of the radiator tubes. Such deposits may impede the circulation and also lessen the radiation of heat from the core. Sediment or foreign matter contained in the water has the same effect as scale; hence often it is desirable to strain the water when filling the radiator. Sediment may lodge in water jackets also and prevent the transfer of heat to cooling water, causing worn pistons, scored cylinders, etc.

2. Flush out the radiator and cooling system with clean water after each month of service. Drain the system when it is hot. Disconnect top and bottom connections; at the top of the radiator, pour water in, allowing it to run through. Flush out water jackets in the same manner. Thorough flushing is especially necessary after using anti-freeze solutions, because these are likely to leave a deposit in the radiator tubes.

The following methods are commonly used for removing scale from the interior of the radiator.

(*a*) Dissolve common washing soda in hot water in the proportion of a pound to the gallon, or sufficient to make a saturated solution. Fill the radiator with this solution and run the engine for two or three hours. Then drain it off and flush out with clean water.

(*b*) Fill the radiator with a solution of one part muriatic acid to seven parts of water, and allow it to stand in the cooling system for thirty-six hours. Then drain off the solution and flush out the system thoroughly with clean water.

3. Clean the radiator fins and air passages. The outside as well as the inside of the radiator must be kept clean. If the air passages and fins are covered with dirt, grease, chaff, etc., the efficiency of the radiator is greatly reduced. Such deposits should not be removed by scraping, but should first be brushed off, after which the surfaces may be washed with an old paint brush dipped in kerosene. Where hard water has been used it is advisable to disassemble the radiator completely, as in Fig. 314, for thorough cleaning at the end of each full season's run.

Repair leaking radiator tubes. Locate the exact points in

the tubes where leaks occur. Remove the radiator if necessary to give access to these points, and close the leaks by soldering. In some tractor radiators the tubes are replaceable and are held in position by packing nuts instead of soldered connections. The replacement of a tube in this case is an easy matter.

If the leak in the faulty tube is found to be in an inaccessible position even with the radiator core removed, the top and bottom of the leaking tube may be closed with solder. This will prevent the entrance of water into the tube and will eliminate the trouble. If only a few radiator tubes are cut out of circulation in this manner, the cooling efficiency will not be greatly lessened.

Water Pump

1. If water drips from the packing-gland nuts at the pump, tighten the nuts to see if the leak will stop. Where the drive shaft extends through the pump body, two packing nuts are used, one with a right-hand thread and the other with a left-hand thread. If tightening the nuts does not stop the leak, new packing is necessary.

2. Unscrew both packing nuts and remove the old packing with a cotter pin extractor or a sharp-pointed hook.

3. Insert new packing. Packing used for this purpose is usually asbestos smeared with graphite. It may be secured in string form or in a spiral ring. Where the latter is used, it should be the proper size to fill the gland correctly. The packing is wrapped around the shaft and cut as shown in Fig. 318. The joints between the packing rings thus cut should be spaced so that they do not fall in line.

4. Force in a small amount of packing at a time (one or two rings) by turning up the packing nut. Then back off the nut and add more packing in the same manner. This aids in fitting and shaping the packing to the gland.

5. Where string or wick packing is used, several turns of packing may be wound on the shaft and then forced into the gland with the packing nut. If too much packing is used the

gland nut will not have sufficient threads in contact and may be stripped. Brass nuts are used and care is necessary to prevent stripping.

The pin or key securing the impeller blade to the pump-driving shaft is made to shear off if the water in the pump is frozen. This condition is often difficult to detect, as the pump-driving shaft will revolve and the pump will therefore appear to be working properly when in reality the impeller is not turning.

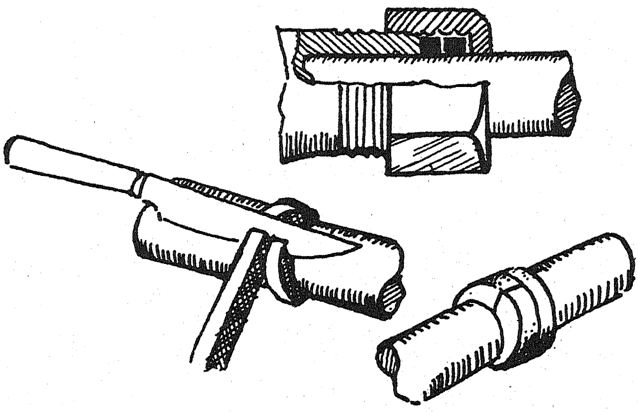


FIG. 318. Packing the water pump.

In some makes of tractors, the bearings of the water-pump drive shaft are carried on specially designed, graphite-packed bearings that require no lubrication, but in most makes these bearings require lubrication one or more times daily.

Drain cocks are always provided for drawing off the water from the system during freezing weather. In some makes a single drain cock, placed at the bottom of the radiator, will thoroughly drain all parts of the system, but in others a drain cock is placed at the bottom of the pump and another at the lowest point in the water jacket. The operator should locate all such drain cocks and make sure that all the water is removed from the cooling system when necessary.

The tractor operator should use only such anti-freeze solutions as are recommended by the manufacturer.

Fan

In addition to lubricating the fan bearings regularly, the operator should see that the fan belt is properly adjusted.

Belt-driven Fans

Belt-driven fans are always provided with means for tightening the belt. The three most common methods follow.

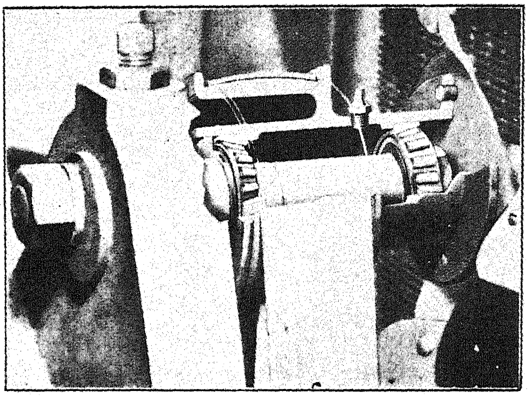


FIG. 319. Fan, fan shaft, and bearings.

1. *Spring Tension.* The fan pulley is mounted in an adjustable bracket controlled by spring tension. In this design it is only necessary to increase the tension of the spring to tighten the belt.

2. *Eccentric* (Fig. 319). The fan shaft and bearings are mounted in an eccentric casting, which is clamped in place by cap screws. By loosening the cap screws, the eccentric may be turned to a new position.

3. *V-belt* (Fig. 320). Where V-belts are used, the rims of the fan drive pulley form a V to receive the belt. The front

rim is threaded on to the fan hub. To tighten the belt, loosen the setscrew and screw the front rim (B) to the right. Bringing the two rims closer together causes the belt to ride higher in the groove, thus tightening the belt. Lock the setscrew again when adjustment is completed. In tractors having an automotive type of electrical system, such as described on p. 446,

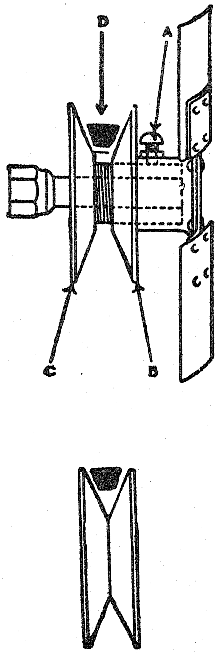


Fig. 320. Adjustment of V-type fan belt.

the generator and its driving pulley may be shifted outward so as to adjust the tension of the fan belt. In this case one V-belt drives both the fan and the generator.

The tension should be just enough to prevent slippage at normal engine speed. A slight slip when the engine starts is desirable, to avoid strains on the fan if the engine starts or accelerates suddenly.

Gear-driven Fans

Gear-driven fans are provided with friction members so that a slight slippage occurs in starting or in sudden changes of engine speed. An adjusting nut is provided to regulate the tension between these members, which should be set so that a pull of 10 to 15 pounds at the extreme edge of the fan blade will just move the fan. If excessive slippage occurs, the friction surfaces may be worked out.

Fan Blades

Inspect the blades for loose rivets or bent blades. The angle of all blades should be the same. If blades become bent out of shape they may interfere with the proper operation of the cooling system.

Fan-shaft Bearings

Test fan-shaft bearings by rocking the shaft up and down, and also test for end play in the bearings. If excessive looseness is noticed, adjustment or replacement of the bearings is necessary. (See p. 484.)

CHAPTER XVI

TRANSMISSION SYSTEMS

The power of the engine must be transmitted to the driving members for propelling the tractor, to the pulley for operating belt-driven machines, to the power take-off shaft for operating the mechanism of other implements, and to the lifting device for raising and lowering implements. This power must be easily controlled and regulated and must be available in suitable speeds for these different functions.

Clutch

The clutch enables the operator to control the power of the engine; to apply or connect this power to the various gears and shafts which carry it to the drive wheels, belt pulley or power take-off; and to disconnect the engine power from these parts when desired.

A well-designed tractor clutch must fulfil these following requirements.

1. It must make possible a gradual "pick-up" of the load, so that the engine power may be applied gradually and smoothly, without jerking.
2. The clutch must not slip after it is completely engaged.
3. Access for adjustment of the clutch should be easy.
4. Convenient and dependable means of lubricating the clutch bearings must be provided.
5. Seals or other means to prevent overlubrication and oil leakage on to the friction members (where these are designed to run dry) should be provided.

The clutches used on farm tractors are of the friction type, as they depend upon the friction between two or more mem-

bers for connecting and applying the power of the engine as above mentioned. One set of these friction members is positively driven by the engine flywheel and always revolves with the engine. The other set is attached to a shaft which conveys the power to the transmission parts. The pressure necessary to hold the friction members together is secured by spring pressure or by an arrangement of small levers. In the latter type no springs are required.

Spring-pressure Type

A simple type of spring-pressure clutch is shown in Fig. 321*A* and *B*. It is made up of the following parts.

Clutch Plates (*d* and *e*). This clutch has two plates. One is connected to the flywheel of the engine, and the other to the transmission shaft. The second plate is keyed to the transmission shaft so it can slide back and forth through a short distance. Both of these plates are lined with fiber.

Clutch Spring (*a*). The clutch spring is usually a heavy coil spring which presses the two plates of the clutch tightly together when the clutch is engaged.

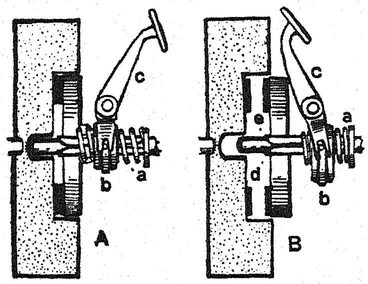


Fig. 321. Simple type of spring-pressure clutch. *a*—Coil spring. *b*—Shifting yoke. *c*—Foot pedal. *d* and *e*—Friction rings.

Clutch Yoke (*b*). The clutch yoke fits into a groove cut around the rear clutch plate. The clutch yoke connects the rear plate of the clutch to the clutch lever or pedal.

Clutch Lever or Pedal (*c*). The clutch lever may be either a foot pedal or a hand lever. It is used by the operator to engage or disengage the clutch. The clutch lever is always connected to the clutch-shifting yoke.

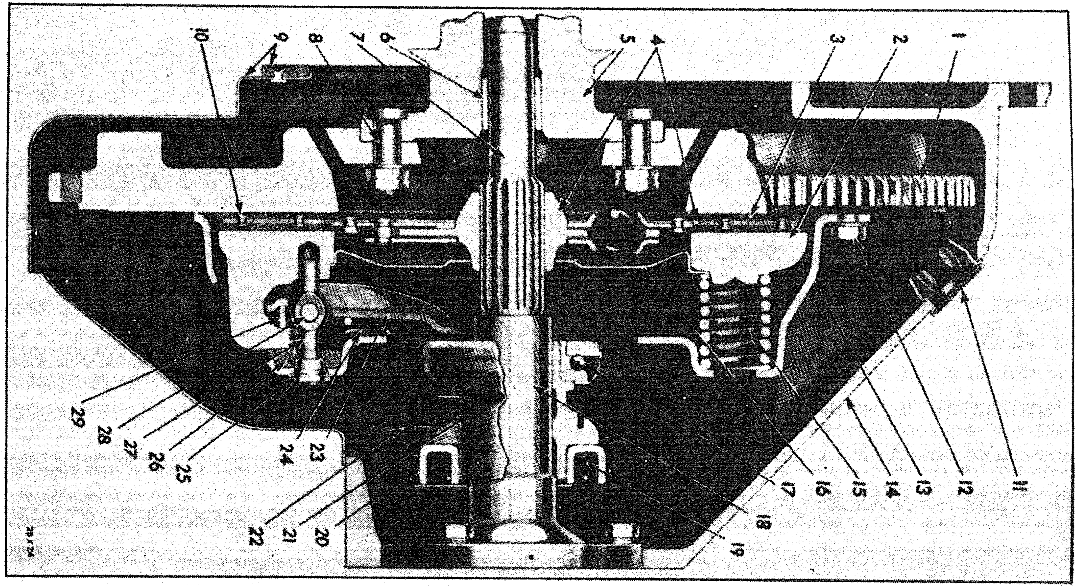


FIG. 322. Spring-pressure clutch. 1—Flywheel and ring gear. 2—Pressure plate. 3—Disk facing. 4—Disk assembly. 5—Engine crank shaft. 6—Crank shaft bushing (transmission-drive, pinion-pilot bushing). 7—Transmission-drive pinion. 8—Flywheel bolt. 9—Housing pan and seal. 10—Disk-facing rivet. 11—Housing ventilator screen—small. 12—Cover to flywheel screw and lockwasher. 13—Cover. 14—Housing. 15—Pressure spring. 16—Pressure plate baffle. 17—Release bearing. 18—Transmission-drive, pinion-bearing retainer. 19—Release-bearing pull-back spring. 20—Release fork. 21—Release-bearing sleeve. 22—Clutch housing ventilator. 23—Release lever. 24—Release-lever spring. 25—Release-lever eye-bolt nut. 26—Pressure-plate, driving-lug grease pad. 27—Release-lever eye bolt. 28—Release-lever pin. 29—Release-lever strut.

Proper care of the clutch and caution in operating it are very important. The clutch should be disengaged only while the gears are being shifted in the transmission. If it is kept disengaged long, when the engine is running, the linings on the clutch plates and the clutch-shifting yoke are subjected to unnecessary wear.

A modern type of spring-pressure clutch is shown in Fig. 322.

Lever-pressure Type

The tractor clutch shown in Fig. 323 is a "dry" disk type. It is called dry because the friction members are not lubricated. Earlier designs permitted the friction plates or disks to run in a bath of oil and hence were called "wet plate" clutches.

Principal parts include those listed below.

Driving Member. The driving plate is attached to the flywheel with the clutch pins, and always revolves with it.

Clutch Linings or Friction Rings. These are riveted to the driving plate.

Back Plate (Driven). The long hub of the back plate is keyed to the clutch shaft.

Floating Plate (Driven). The floating plate is mounted on the hub of the back plate. It is pinned to the back plate so that these two must always revolve together, but the pins connecting these two plates permit a slight longitudinal movement (backwards and forward) of the floating plate. Thus, when the clutch is engaged, the floating plate is forced toward the back plate; when disengaged, it is forced away from the back plate.

Clutch Fingers. These small levers (usually four) act to engage and disengage the clutch. The inner ends of the fingers rest on the clutch-shifting cone, and the outer ends bear against the floating plate.

Clutch Cone and Shifting Mechanism. As the clutch shifter is moved toward the flywheel, the ends of the fingers are pressed outward by the inclined surface of the cone, re-

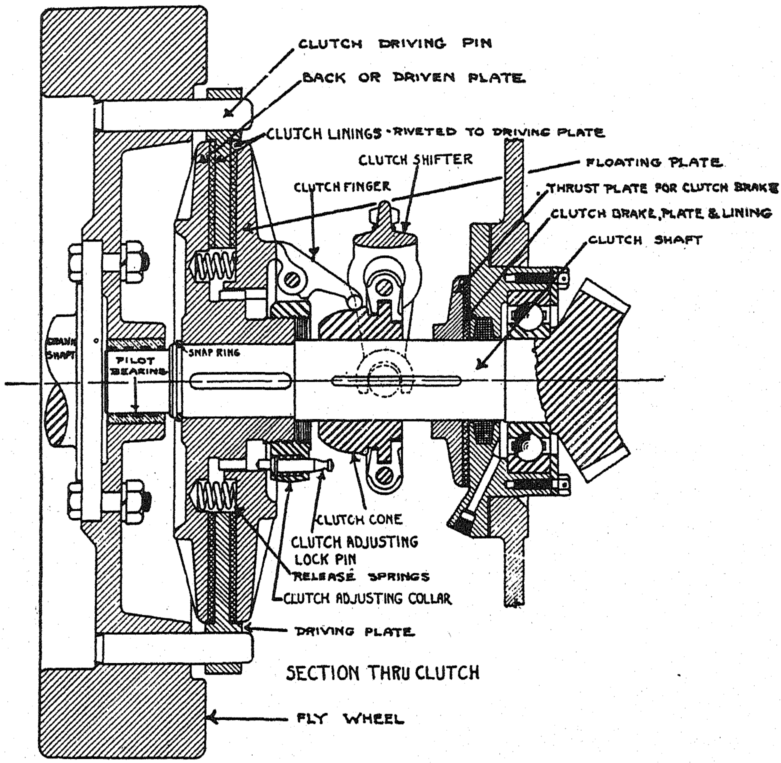


FIG. 323. Lever pressure clutch.

sulting in pressure on the floating plate, which in turn moves forward, clamping the driving plate, back plate, and floating plate securely together.

Release Springs. The small release springs (usually four) aid in retracting the floating plate when the clutch is disengaged.

Adjusting Collar. Adjustment is made easy by a conveniently located clutch-adjusting collar, which is screwed onto the end of the hub of the back plate. The lock pin passes through the collar and engages in a hole in the face of the floating plate. To tighten the clutch, the lock pin is pulled out and the collar screwed clockwise, or further onto the hub of the driven plate. Then the pin is released and snaps back into the next hole in the floating plate. A series of holes are provided all around the floating plate.

Clutch Brake. The clutch brake is in front on the main-clutch shaft bearing. When the clutch is disengaged, the rear surface of the clutch cone clamps the lining of the brake against the stationary surface of the bearing cage, thus preventing the clutch shaft from spinning, and facilitating gear shifting.

This type of clutch is operated with a hand lever. The spring-pressure type is operated with a foot pedal. If the hand lever is well placed, the operator may manipulate the clutch while standing on the ground. This is convenient when backing up to an implement.

JOB 28

CARE AND ADJUSTMENT OF THE CLUTCH

(Refer to Manufacturer's Instruction Book)

Procedure

Lubrication

In most designs the clutch throwout yoke or shifter should be lubricated frequently. This bearing may be subjected to heat and rapid wear, particularly when a careless operator uses the clutch pedal as a foot rest. Manufacturer's directions for lubricating this and other clutch-operating bearings are given in the instruction book and should be carefully followed. A few designs require no special lubrication of the clutch-release bearing; some are permanently lubricated with a spe-

cial lubricant when manufactured, and other types receive lubrication from the engine oil supply.

"Free Play" of Clutch Pedal (or Lever)

As the facing of the clutch wears, the release levers or yoke move outward toward the release bearing or shifter. This tends to disengage the clutch partially or to cause the condition known as a *riding clutch.* The same condition is caused when the operator rests his foot on the clutch pedal. To prevent this, there should be a free movement of 1 inch in the clutch pedal or lever. It should be possible to move the pedal, or lever, by hand before feeling the heavy resistance of the clutch pressure.

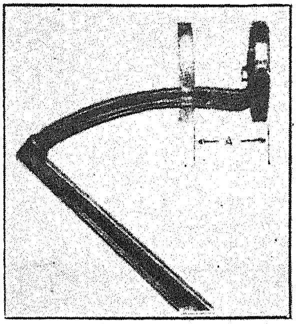


FIG. 324. Free play in clutch pedal.

Adjust the linkage between the pedal and the release mechanism to give the specified clearance. (See Fig. 324.)

Pressure Adjustment

The pressure between the plates of spring type clutches is usually not adjustable, because strong, heavy springs provide permanent pressure. In a few types it is possible to tighten the springs and increase pressure between the plates.

Lever Pressure Type (Fig. 323)

1. Remove handhole or inspection plate to give access to the clutch.

2. Put the gear-shift lever in neutral and disengage the clutch.

3. Turn the clutch by hand until the adjusting pin can be easily reached.

4. Put any set of the speed-change gears in mesh so that the clutch shaft will not turn.

5. Pull the adjusting pin out (toward the rear), using a

screwdriver or pronged tool if necessary. Turn the adjusting collar to the right while the adjusting pin is held out. This will usually turn easily when the clutch is disengaged, but it may be necessary to pry it around. Turn the collar far enough so the adjusting pin will engage in the next hole, making sure that the adjusting pin is properly entered in the new hole before engaging the clutch.

6. Test the adjustment by engaging the clutch. It should be such that a firm but not excessive pressure is required on the clutch lever to cause engagement, and it should engage with a distinct snap.

7. Repeat the adjustment if necessary, moving the lock pin one hole at a time until the correct adjustment is obtained.

Transmission

Tractors are used for many different kinds of work. It may be necessary to use a tractor to pull a very heavy load up a steep hill. In this event, the engine must run at rated speed, but the rear wheels must turn slowly. Or it may be necessary to pull a light load along a good, level road by means of a tractor. In this case it would be desirable to have the rear wheels turn faster in relation to the engine speed. Several sets of gears are needed for these different conditions.

For moving forward, most tractors have at least three different speeds or "gear changes" (sets of gears) in the transmission and one set of gears for moving backwards.

The center shaft (Fig. 325) is a splined shaft. When the clutch is engaged this shaft is connected to the engine flywheel. The single pinion (*A*) and the double pinion (*B-C*) are fitted over this splined shaft. They may be shifted along the shaft by means of the gear-shifting lever, but always they revolve with the shaft. Directly below the splined shaft is a second shaft to which three gears are secured, so spaced that each is almost directly below one of the sliding pinions on the upper shaft.

Change Speed Gears. When pinion A is moved backwards into mesh with gear D, the tractor is in high speed. Shifting pinion A forward into mesh with G gives reverse speed. In reverse, the drive is from A to G to H to E, and then through the remaining gear contacts (IK and MN) to the rear wheels. Second or intermediate speed is obtained by meshing C and E, low speed by meshing B and F.

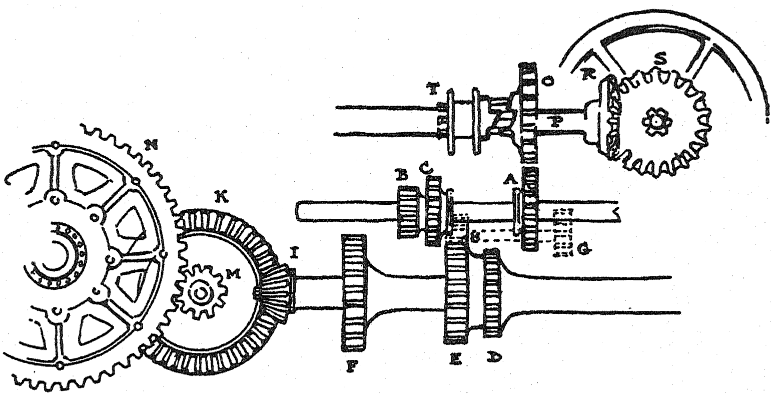


FIG. 325. Diagram of transmission system of McCormick Deering 10-20 tractor.

To obtain a proper ratio between the speed of the engine and the rear wheels two more gear contacts are required, the second being between I and K and the third between M and N. The ratio between the speed of the engine and drive wheels for the tractor transmission illustrated in Fig. 384 is: high speed, 29.17 to 1; second speed, 41.5 to 1; low speed, 56.9 to 1; reverse speed, 47.4 to 1.

Belt-pulley Drive. Pinion A is in constant mesh with gear O, which is placed directly above it. In this position, if the small clutch T is engaged, power will be transmitted to the belt pulley through the gears R and S. The clutch T is splined to the upper shaft.

Power Take-off. The power take-off shaft makes it possible to take power from the tractor engine to operate the mechanism of implements that are being drawn behind it, such as grain and corn binders, mowers, potato diggers, combines, and other farm machines.

The drive is from A to O, through the clutch T, to the shaft P, which extends to the rear of the tractor where it couples to an extension shaft which drives the implement. By increasing the width of the teeth in gear O, manufacturers have made the power take-off operative in all speeds.

Gear-shifting Mechanism. The gears on the upper shaft are shifted by the operator with the gear-shifting lever. Whenever a gear is shifted, the clutch must be thrown out so that the gears on the bottom shaft stop revolving. If this is not done, the gears will grind together and may be ruined.

When the gears are set so that none are in mesh between the bottom and top shafts, they are said to be "in neutral." They should always be placed in neutral before starting the engine.

The gear-shifting shaft, on which the shifting forks are carried, is provided with notches, as shown in Fig. 326. The shifting shaft in the construction illustrated is stationary. In other types, the shifting yoke is bolted to the shaft and both the yoke and shaft are shifted.

Stop pins or plungers actuated by small coil springs engage in these notches when the gear-shifting lever is shifted into any desired position.

Proper mesh or full-width contact between gears should be obtained when the stop pin is engaged in one notch. When the gear-shifting lever is moved to the neutral position, the stop pin will engage in the next notch, etc. The function of the notches and stop pins is to hold the sliding gears firmly in the desired position and prevent their working out of place through vibration. Two methods of adjustment are commonly used.

(*a*) Move the yoke along the shaft by loosening the bolt which clamps it to the shaft.

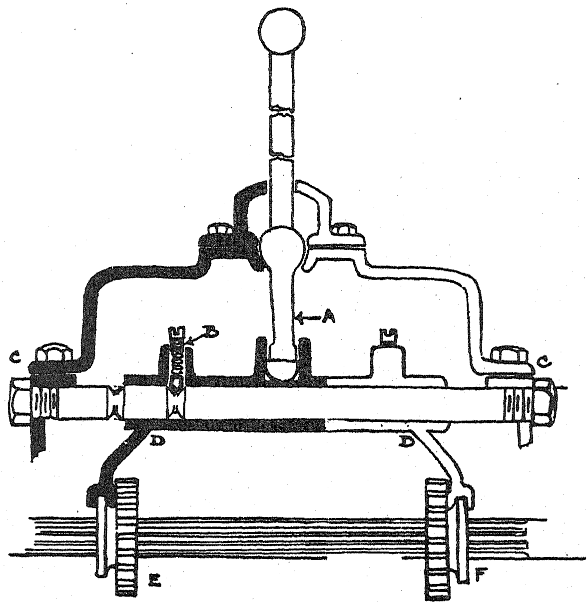


FIG. 326. One type of gear-shifting mechanism. *A*—Shifting lever. *B*—Stop pin and spring. *C*—Adjusting nuts for gear-shifting shaft. *D*—Shifting yoke or fork. *E* and *F*—Sliding gears.

(*b*) The entire shaft may be moved in either direction with an adjusting screw (this construction is shown in Fig. 326).

Differential. As both rear wheels are drive wheels, some means must be provided to permit one to turn faster than the other when a corner is turned, as the wheel on the outside of the turn must travel farther than the one on the inside. Both wheels, also, must do their share in pulling the load. This is accomplished by means of the differential. The differential shown in Fig. 327 is located midway between the two drive

wheels. The various parts of the differential include the worm wheel or bevel gear (often called ring gear), four differential bevel pinions which are mounted on small axles carried in the differential housing, two beveled axle gears (called differential gears or axle gears) which are splined onto the rear axles, and the two differential cases or housings which are slipped over the axles and are bolted to the worm gear. The differential is

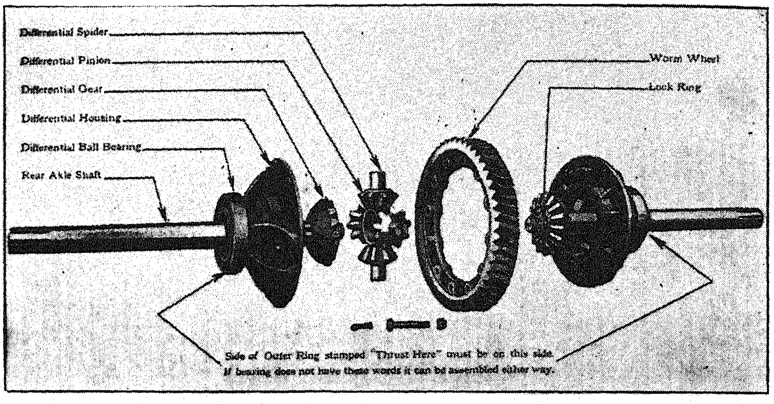


FIG. 327. Parts of the differential.

supported by bearings which are mounted on the projecting hubs of the differential cases and which fit into the large transmission housing. When the differential is assembled, both axle gears slip into mesh with the four differential pinions. If the tractor is moving straight forward, the entire differential assembly revolves as a unit, the differential pinions do not rotate on their stub axles, but are simply carried around with the worm gear. Both axle gears and, accordingly, both rear wheels are driven equally. But when one wheel meets with additional resistance, as when turning a corner, the differential pinions begin to rotate on their short stub axles. This results in their "riding" on one axle gear and "driving" the other, so that one wheel is driven faster than the other.

This differential action also occurs when one wheel is on

soft or slippery ground and the other on firm ground, as the unequal resistance will cause one wheel to spin. To overcome this difficulty, some manufacturers of tractors provide a differential lock or brake which prevents differential action under such conditions.

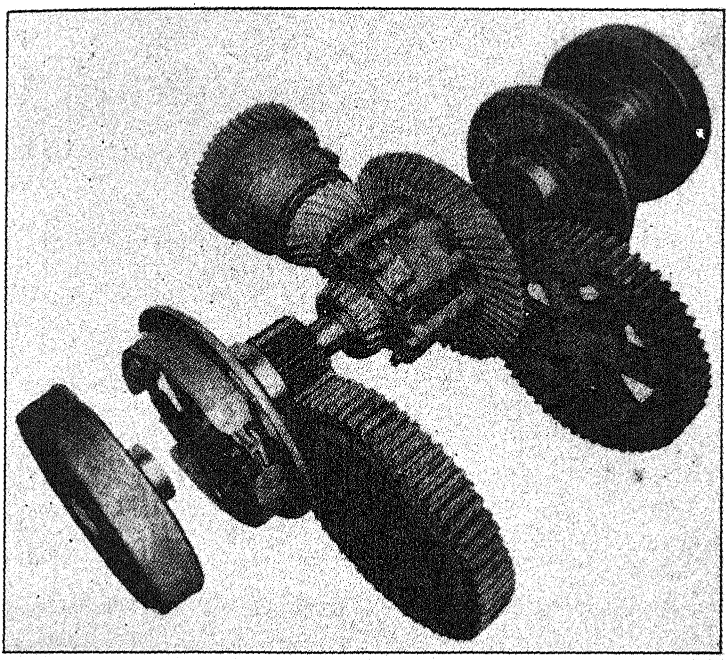


FIG. 328*A*. Final drive gears, brakes, differential, and drive pinion of Minneapolis-Moline tractor.

A differential brake may be installed at each side of the differential on each rear axle shaft. When one of these brakes is applied, it gives differential action and assists in short turning. If both differential brakes are applied at once, both wheels are retarded equally.

Final Drive. Various methods of applying the power to the drive wheels are used, through chains, by means of a worm

and worm gear, or by a spur pinion and large spur gear as shown in Fig. 325.

All parts of typical power-transmission systems are shown in Fig. 328*A* and Fig. 328 *B*.

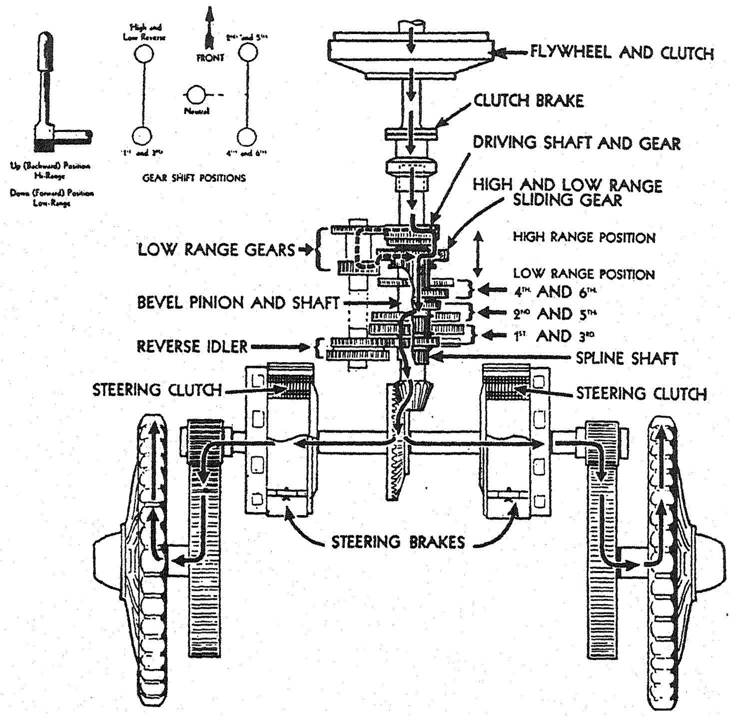


Fig. 328*B*. Transmission of International tracklaying tractor.

Bearings of the Transmission System

The shafts used in a transmission system must be supported by bearings of sufficient size and capacity to carry the heavy loads demanded by the rough work of the farm. Good bearings are essential, and their importance is often underestimated. Without suitable bearings, the clutch shaft and the various transmission shafts could not be kept in the proper position,

but would twist and weave out of line; gears would mesh together too deeply or too lightly; noisy gears and pounding shafts would result, accompanied by excessive heating, friction and wear. The functions of the bearings are to support the weight of the transmission shafts and gears, to carry the loads that may be placed upon such parts without permitting their alignment or relation with each other to be disturbed, and to reduce friction.

Plain Bearings. When a revolving shaft is supported by a fixed-bearing surface of metal, it is said to have a plain bearing. The metal used may be cast iron, chilled cast iron, brass, babbitt, bronze, and phosphor bronze, etc. Plain bearings faced with babbitt, bronze, and phosphor bronze are generally used in the various parts of the tractor engine where the heavy thrust of the power impulses must be spread over a considerable amount of bearing surface. Plain bearings carry heavy loads well and may be made of high quality, wear-resisting metal, but even though well lubricated they use a comparatively large amount of energy because of their high friction.

Plain bearings are also used on many other parts of the tractor where losses due to friction need not be considered, such as brake pedals, pivot pins, steering-gear connections, springs, etc.

As bearings of this type have a large amount of friction surface and are closely fitted, they should be lubricated with a light oil because such a lubricant will be distributed easily over the entire bearing surface.

Anti-friction Bearings. Bearings used in a transmission system are usually of the type called *anti-friction*, for friction within them is much less than in a plain bearing. Consequently, the power losses within the transmission are greatly reduced. In all anti-friction bearings, steel rollers or balls are placed between the two surfaces under load; thus a rolling friction

is substituted for the sliding or rubbing friction of a plain bearing. Their construction is such that they will maintain accurate alignment between the parts they support. They will carry well the varying complex loads and sudden thrusts that are placed on these parts. They will last long and wear well if properly lubricated and protected from grit and moisture; some types are adjustable, and may be taken up as they wear. To lubricate anti-friction bearings is easier than to lubricate plain bearings. Anti-friction bearings will retain a supply of lubricant longer. There is less tendency for it to be squeezed out, as the friction area is smaller, and usually a heavier and more lasting lubricant may be used with anti-friction bearings than with plain bearings.

The steel balls or rollers used between the load surfaces have given rise to the terms "ball bearings" and "roller bearings." Anti-friction bearings are used in general throughout the transmission system, and they are being used to some extent on engine crank shafts.

Loads on Bearings. The loads or forces that bearings must carry are of three distinct kinds. (See Fig. 329.)

1. *Radial Load* (Fig. 329*A*). When a pressure or load is exerted at right angles to that shaft supported by a bearing, the bearing is said to be under a radial load.

2. *Thrust Load* (Fig. 329*B*). A pressure that acts in a direction parallel to the shaft is called a "thrust" load. As such a force would tend to shift the shaft out of place, a special thrust bearing, or sometimes a plain, hardened steel washer is used to absorb loads of this nature.

3. *Combination Thrust and Radial Loads* (Fig. 329*C* and *D*). Frequently, a bearing is subjected to both thrust and radial loads. The bevel gears are subjected to combined thrust and radial loads. The bearings carrying the front wheels are subjected chiefly to a radial load when the tractor is moving over level ground, but when it is turning a corner a heavy thrust load also occurs. Thus, a bearing at these points must be capable of carrying both thrust and radial loads.

Thus the bearing for each point in the tractor-transmission system must be carefully selected according to the kind of load existing at that point.

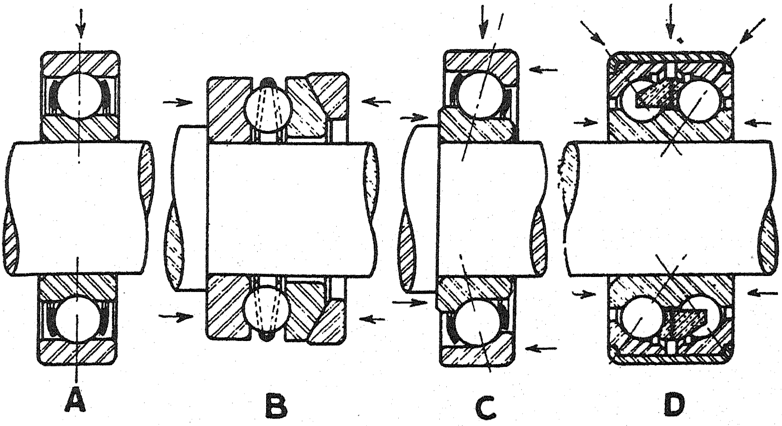


FIG. 329. Loads on bearings. *A*—Radial load. *B*—Thrust load. *C* and *D*—Combined radial and thrust loads.

Types of Ball Bearings

Single-row Annular (Fig. 329*A*). These are designed to carry radial loads only, and are used at points in the transmission system where only such loads exist. They are frequently used in the pilot bearing of the clutch shaft (see sectional view, Fig. 330).

Ball-thrust Bearings (Fig. 329*B*). At certain points on the tractor, such as on the clutch-release, throwout bearing, a special thrust bearing is necessary. This carries thrust load only.

Angular-contact Ball Bearings (Fig. 329*C*). By virtue of the angular contact between the balls and the inner and outer races, this type will carry a radial load and a thrust load from one direction.

Double-row Ball Bearings (Fig. 329*D*). This type is designed to carry a radial load and a thrust load from any direc-

tion. It is made possible by the angular contact between each row of balls and the inner and outer races.

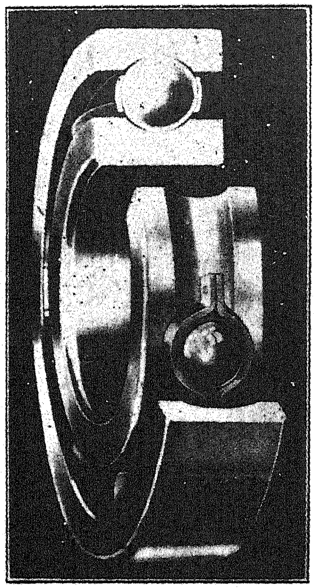


FIG. 330. Sectional view of a single-row annular ball bearing.

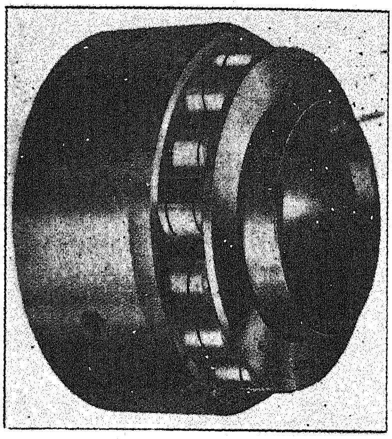


FIG. 331. Straight roller bearing, showing inner and outer races and roller assembly.

Types of Roller Bearings

Roller bearings may be divided into two main classes according to the shape and placement of the rollers. Roller bearings may be straight or tapered. Another classification might be based on the roller itself, which may be hollow, solid, or spirally wound. Roller bearings are usually separable in that the two load-carrying surfaces may be easily separated from each other. Most designs of ball bearings are non-separable.

Straight Roller Bearings (Fig. 331). This type is usually employed for carrying radial loads only, but it is also used in

combination with thrust bearings or thrust washers at points where thrust loads are encountered.

This type is separable, and the parts may be assembled separately. The inner race may be pressed onto the shaft, the outer race into the housing, and the roller assembly may then be slipped between the races.

In some installations, the inner race is eliminated and the roller assembly is mounted directly on the shaft, which serves as the inner race. This requires a shaft of proper hardness.

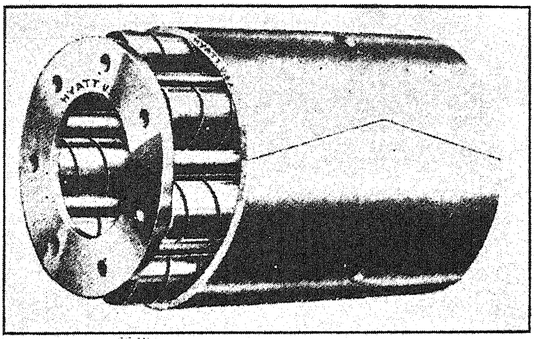


FIG. 332. Roller bearing with split outer race.

In others, a split outer race is used (Fig. 332). The split or cut in the race gives it an outward spring; but, when the race is pushed into the bore, this split closes, the joint is closed, and the outward pressure or spring secures the race in the housing and prevents turning or creeping. This type of bearing is frequently used on the fan shaft of tractors.

Needle Bearing (Fig. 333). This type is designed to replace plain bushings, especially in small spaces. It is used on the pilot bearing of the clutches (the front end of the clutch shaft, which bears in the flywheel) and in many locations on tractors beside the transmission system. It is also used at many points in various farm implements. The hardened, outer shell contains a large number of small, hardened rollers with

pointed ends (needles). They give many inches of line contact and thus permit the use of an anti-friction bearing in small spaces.

Tapered Roller Bearings (Fig. 334). Bearings of the tapered-roller type will carry radial or thrust loads or a com-

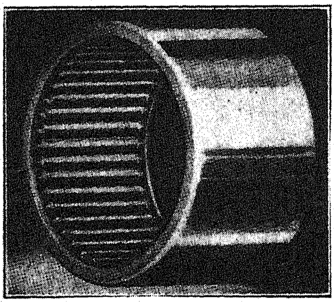


Fig. 333. Needle bearing.

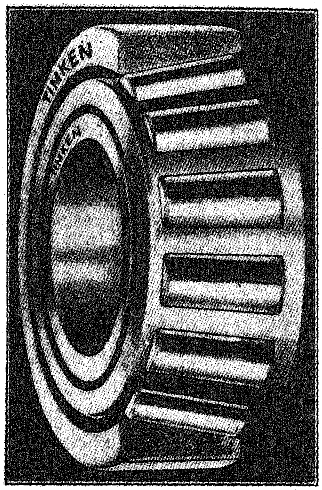


Fig. 334. Cutaway view of completed assembly of tapered roller bearing.

bination of both. They successfully carry heavy loads but are not widely used for excessively high speeds. They are usually mounted in pairs because a heavy radial load on one end of a shaft, supported by a tapered roller bearing, sets up a thrust load on the opposite end, owing to the tapered bearing surfaces. The cone is pressed onto the shaft with a light- or heavy-press fit, according to the type of installation and service. The cup, or outer race, is likewise pressed into the bearing housing. Adjustment for wear is made by bringing the two tapered surfaces closer together.

JOB 29

ADJUSTMENT, CARE, AND REPLACEMENT OF ANTI-FRICTION BEARINGS

Adjustment of different types of anti-friction bearings (chiefly tapered roller bearings) consists in bringing the load-carrying surfaces closer together. This results in lessened end play as well as vertical play in the shafts supported by such bearings. In tractor installations two methods of adjustment are used.

Adjustment by Shims

Remove bearing cap, Fig. 335, 12, by taking out the retaining bolts.

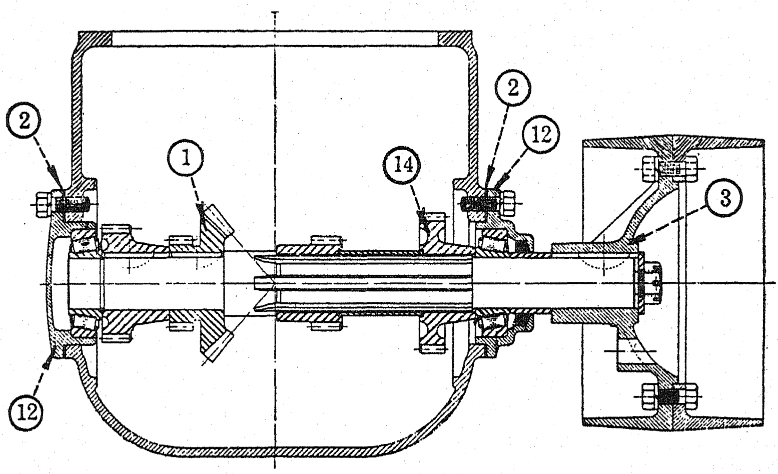


FIG. 335. Adjusting bearings of belt-pulley shaft by removing shims.

Remove one thin shim Fig. 335, 2.

Replace and tighten down the bearing cap and test the shaft for end play. The removal of a shim, in this method of adjustment, causes the bearing cap to push the outer or stationary race further on the inclined surface of the roller, thus tightening the bearing.

Remove additional shims in the same manner if necessary. Shafts should not be permitted to have an end play more than 0.002 to 0.006 inch unless otherwise specified in the manu-

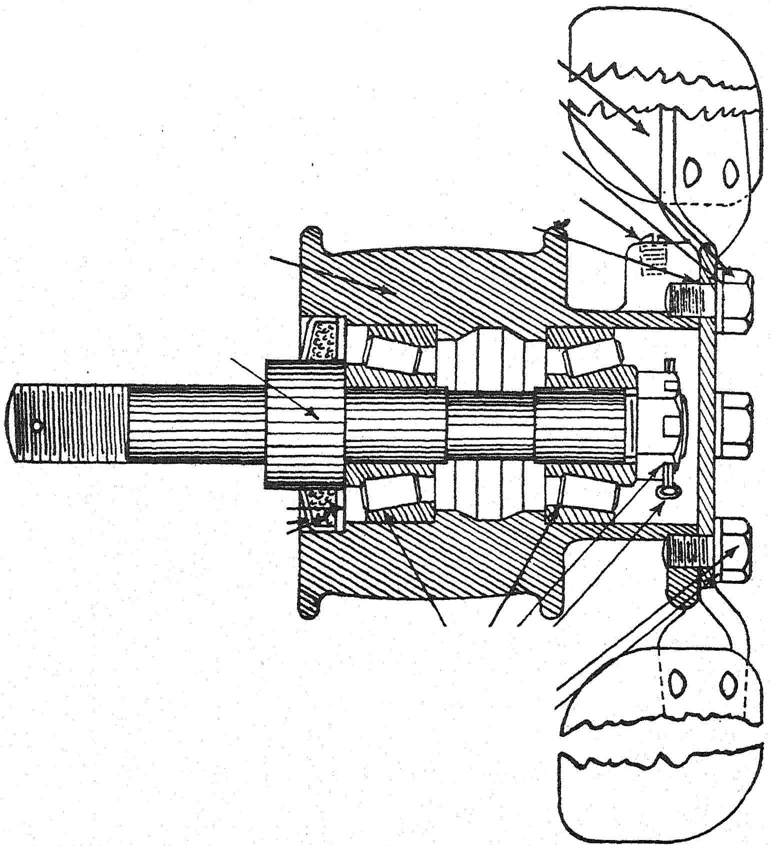


FIG. 336. Threaded nut adjustment of bearings on fan shaft.

facturer's instructions. This means that the shaft will have a barely perceptible end play. In large bearings such as those supporting the rear axles, the shims are sometimes made in halves. In this case, it is essential to remove shims of equal thickness from both upper and lower half of the bearing cap.

Tighten equally all the cap screws, retaining the bearing cap when the adjustment is satisfactory.

Adjustment by Threaded Nuts (Fan Driving Pulley As an Example)

Remove the cotter key in the end of the adjustment nut, Fig. 336.

Tighten the castellated nut until all end play in the shaft is eliminated and the fan-pulley assembly is tight on the bearings.

Back off the adjusting nut just enough to make the fan pulley spin freely.

Reinsert and spread the cotter key.

The adjustment illustrated in Fig. 335 is made by the movement of the outer race; that in Fig. 336 is obtained through the movement of the inner race. The former adjustment is on a revolving shaft and the latter on a stationary shaft.

JOB 30

ADJUSTMENT OF BEVEL GEAR AND PINION

NOTE. Grinding or whining noise indicates that the bevel pinion and gear are meshed too tightly—teeth bottom.

Loose or rattling sound indicates too loose mesh, or that the pinion and gear are out of line, which may cause breakage. When they are properly meshed, there will be a 0.010 to 0.015 inch play or backlash between the gear teeth. (See Fig. 337.) The ends of the teeth of the pinion and gear should be flush with each other; one should not extend out from the other. This adjustment is not often necessary except after several years of service.

Procedure

1. Adjust the bevel gear to the pinion, as required, to get the proper mesh between the teeth. To accomplish this, the bearings supporting the shaft that carries the bevel gear are adjusted to move the gear toward or away from the pinion.

This is accomplished by tightening the bearing on one end

of the shaft and loosening the opposite bearing or thrust plate, enabling the shaft to be moved endwise.

If shim adjustment is provided, the bevel gear may be moved to the right or left, as necessary, by removing shims from one bearing cap and adding them to the opposite bearing cap.

2. Although moving the bevel gear only is usually sufficient to get a correct adjustment, it may also be desirable to move the pinion slightly backwards or forward in order to make the edges of the teeth meet evenly. Provision is made for this, in some tractors, by the adjustment of the bearing that supports the shaft carrying the bevel pinion, either by shim adjustment or by threaded-nut adjustment.

3. Test.

(*a*) Test both shafts for end play.
(*b*) Test the amount of backlash.
(*c*) Test the adjustment carefully, after it seems satisfactory, by cranking the engine sufficiently to turn the bevel gear a complete revolution (jacking up the rear of the tractor if necessary), to make sure that the teeth mesh properly at all points and do not bind.

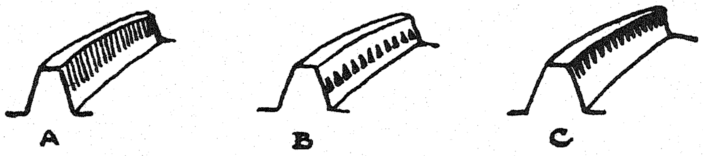


FIG. 337. Contact between gear teeth. *A*—Correct—full face contact. *B*—Gears meshed too deeply. *C*—Gears not meshed deeply enough.

The meshing of the gear teeth may also be determined by noting the teeth of the bevel gear, after cranking the engine so that the bevel gear has made several revolutions. Inspection will then reveal how they are meshed with the pinion. The portion of the bevel gear teeth from which the oil has been wiped off by the pinion is the part in actual contact. This

should show, as indicated in Fig. 337*A*, a full contact across the entire width of the tooth and no contact at the bottom of the flank of the tooth. If contact extends too far down on the flank of the tooth, as shown at *B*, noisy gears will result. If the contact is not deep enough but exists only at the upper portion of the face of the tooth as at *C*, rapid wear and possibly breakage will occur. In this case, excessive backlash will be evident and the bevel gear should be adjusted toward pinion.

CHAPTER XVII

FRONT AXLE, FRONT WHEELS, AND STEERING GEAR

Front-axle Construction (Standard Four-wheel Type)

Front Bolster (Fig. 338). The weight of the forward end of the tractor is carried on the front axle. The bolster connects the front end of the tractor to the axle. The bolster may be riveted or bolted to the main frame of the tractor, or it may be in the form of a bracket bolted directly to the engine. In some designs, a spring mounting is used between the bolster and the front axle.

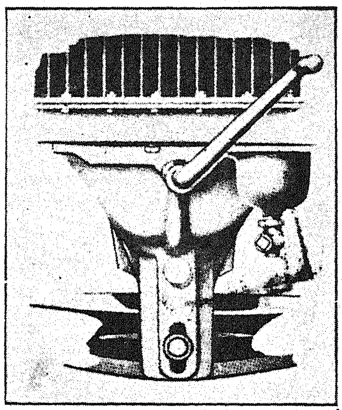


Fig. 338. Front bolster used to connect engine to front axle.

Front Axle (Fig. 339). The center of the axle is attached to the bolster with a king pin or trunnion to provide a pivotal connection, to give flexibility when traveling over uneven

ground. Means are provided for the lubrication of this connection.

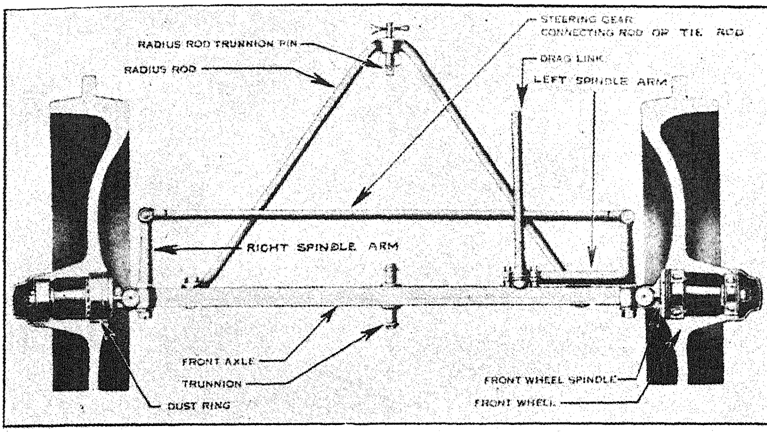


Fig. 339. Front axle, wheels, and steering gear parts.

Radius Rod or Stay Rod (Fig. 339). The alignment of the front axle is maintained by the use of a brace, referred to as a radius rod, stay rod, or reach, the front ends of which are bolted near the outer ends of the axle. The rear end is attached to a pivotal connection placed beneath and near the rear end of the engine so that the axle is held in alignment but not prevented from rocking freely on the trunnion pin through the axle.

Steering Knuckles or Spindles (Figs. 340 and 341). The distinctive feature of the automotive type steering gear and front-axle construction is the spindles or steering knuckles. These are short pivotal axles attached to the outer ends of the front axle with pivotal pins or bolts called spindle pins.

Spindle Arms (Fig. 340). The spindle arms are attached to the spindles and connect them to the steering gear.

Tie-rod (Fig. 339). A connection between the two steering knuckles, causing them to act simultaneously in steering, is

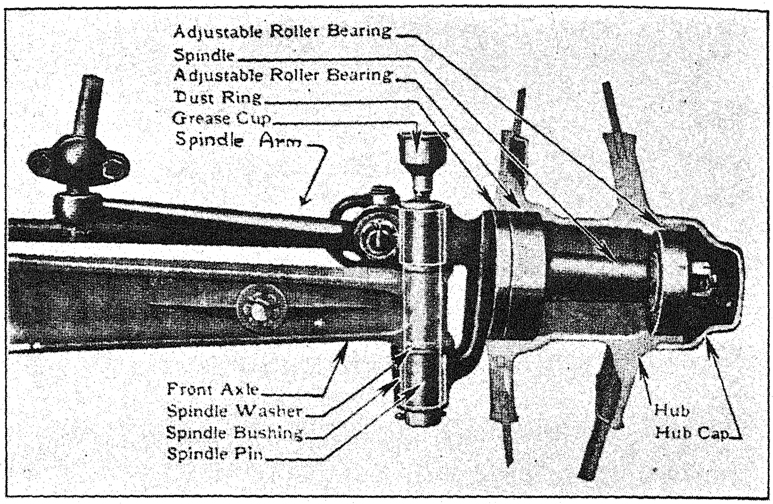


FIG. 340. Detail of spindle or steering knuckle.

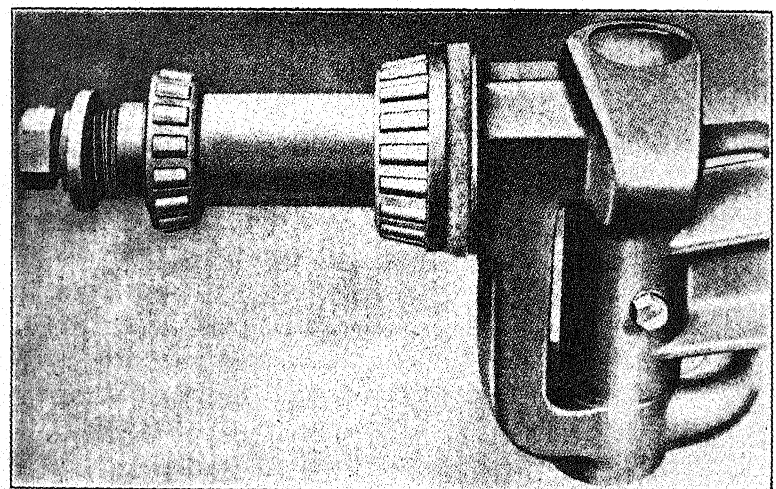


FIG. 341. Front-wheel bearings and spindle.

made by means of a connecting rod. The length of this rod may be adjusted by means of the screw clevises at the ends (or a similar device) to give the wheels proper alignment. (See Fig. 339.)

Steering-gear Parts (Worm and Gear Type) (Fig. 342). The steering wheel is connected to the upper end of the steer-

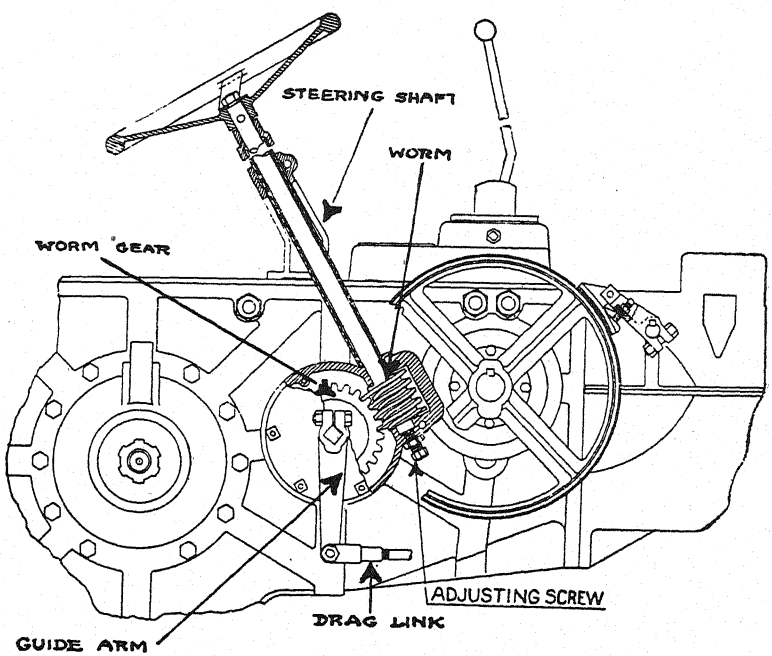


FIG. 342. Detail of steering-gear parts.

ing shaft, and the lower end is fitted with a worm, which meshes with a worm gear. The gear is keyed to a short shaft, the outer end of which is squared, and the steering-gear guide arm is clamped to it. The drag link carries the motion of the guide arm to one of the knuckle arms, which by means of the tie-rod moves the other steering knuckle also.

Stops are usually provided on the knuckle arms or front axle

to prevent too short turning, which might cause the front wheels to rub against the frame, drag link, or some other part of the tractor.

The steering worm and worm gear are carried on suitable bearings, and some means is always provided for taking up wear in these parts. They are either enclosed in an oiltight case, with proper provision for lubrication, or carried within the transmission case.

Differential brakes (p. 475) are used in some models to facilitate steering, particularly when short turning is required.

Wheel Bearings. The front wheels are mounted on the short pivotal axles, which are integral with the spindle. Usually tapered roller bearings are used in the front wheels, as end thrust exists here. They are mounted in pairs, one at the inner and one at the outer end of the pivotal axles. (See Fig. 341.)

Steering-gear Construction on General-purpose Tractors

The front-end and steering-gear construction of the four-wheel type, general-purpose tractor is similar to or an adaptation of the automotive type just described.

The tricycle, general-purpose wheel tractors are steered by the manipulation of what may be called a third wheel, placed at the front of the tractor. This third wheel may be either single or double, but it acts as a single wheel. Where a double wheel is used, the axle is shaped like an inverted T, the wheels being carried on either arm of the T and the end of the stem being connected through gears to the drag link or directly to the steering gear. The entire axle and wheel assembly pivots within the bolster when the steering wheel is turned. This construction is shown in Fig. 136.

Differential brakes are used to assist in steering and for making short turns. In some models they are operated by means of the steering wheel. When the steering wheel is turned enough to make a short turn, the brake is applied. In others, the differential brakes are operated by independent levers.

FRONT-END CONSTRUCTION AND STEERING GEAR OF TRACK-LAYING TRACTORS

In the track-laying type of tractors the front mounting is effected by means of a spring which transfers the weight of

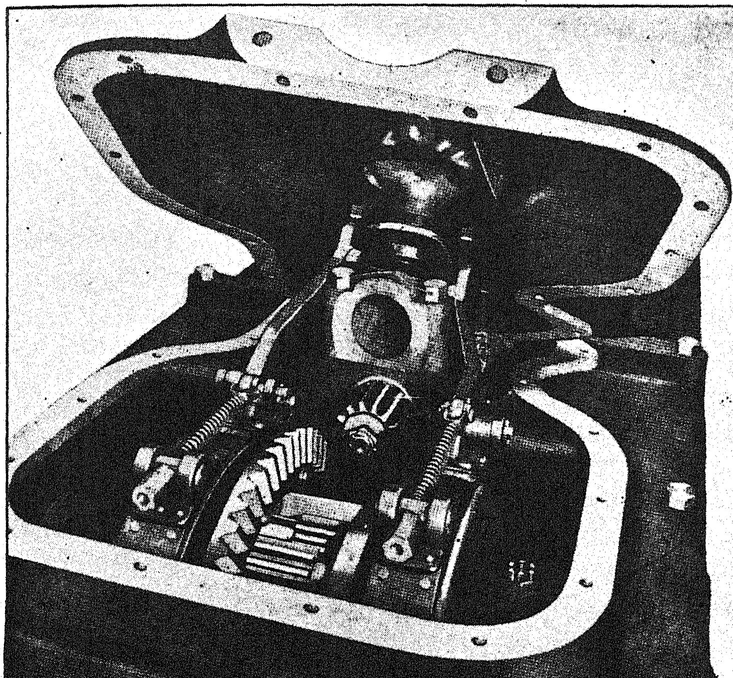


FIG. 343. View showing steering bands used with compensating type of differential.

the forward part of the tractor to the track frames and roller. This spring absorbs the jars of rough travel and permits the track on one side to rise higher than that on the other when passing over obstructions.

Steering is accomplished by varying the power transmitted to the two track-driving sprockets. This may be done by the

use of steering clutches, by differential brakes, or by a differential.

No differential is necessary where steering clutches are used. When one clutch is fully disengaged, the track on that side stops completely and the opposite track drives, causing a short turn. Steering-clutch brakes are also provided to aid in making short turns with light loads; when full loads are being drawn, the brakes need not be used.

The steering device shown in Fig. 343 is a compensating type of differential, or it might be called a combination of a differential and a planetary transmission. The arrangement of gears is such that when the band is compressed on one of the steering drums, the track on the opposite side receives more power and turns faster than the one retarded by the steering band. When the band on either drum is fully compressed, the ratio between track-driving sprockets is about 2.25 to 1. With this type of steering mechanism, both tracks are always driving, even on the shortest turns, it being impossible to stop either track completely.

JOB 31

REPAIR AND ADJUSTMENT OF FRONT WHEELS, AXLES, AND STEERING GEAR

Procedure

Standard Four-wheel Type

Front-wheel Bearings

Jack up one front wheel. To test for worn or loose wheel bearings, grasp the wheel at the top and bottom of the rim and rock the wheel. Shove it in and out on the axle also. If only slight play or wear is noticeable, the bearings may be adjusted by removing the hub cap, taking out the cotter pin or locking device and screwing on the adjusting nut at the end of the axle. Tighten the adjustment nut until the wheel turns hard. Then back it off just enough to make the wheel spin freely.

If the above test shows considerable wear in the wheel bear-

ings, the wheels and bearings should be removed, cleaned and inspected, and replaced if necessary.

To remove the wheel, the hub cap, cotter pin or lock, and adjusting nut must first be removed. (See Fig. 344.) The

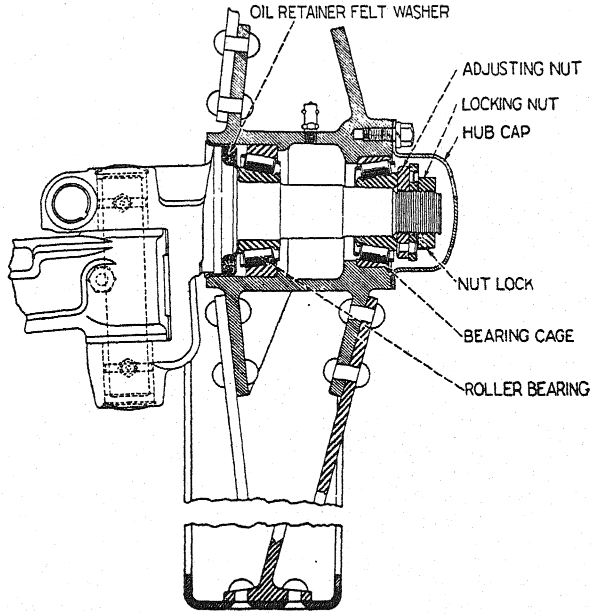


FIG. 344. Construction of front-wheel bearings.

wheel may then be pulled off, bringing the outer bearing with it. The inner bearing may then be pried off with a screwdriver. A felt washer is used behind the inner bearing for the exclusion of dust. If this is in bad condition, it should be replaced. Clean all the parts in gasoline or kerosene, making sure that all grit is washed out of the bearings, and that the old grease is removed from the wheel hub and steering-knuckle axle. Usually it is necessary to replace only the cone and roller assembly of the wheel bearings, but if the outer races (carried in the wheel hub) are rough or cracked they should be replaced also.

Steering Knuckles or Spindles

While the wheel is off, test the steering knuckle for wear between the spindle pins and bushings. (See Fig. 345.) Looseness and wear in these bushings may also cause steering troubles. To remove the bushings, first drive out the steering-

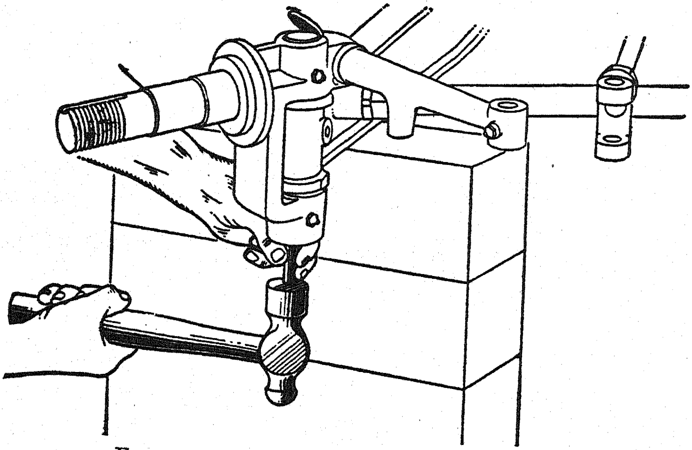


FIG. 345. Removing steering knuckle pins.

knuckle pin. This pin is retained with a bolt and is protected from dust by a plug inserted in the top of the steering knuckle. After the retaining bolt is withdrawn, the knuckle pin may be driven upward and out, carrying the plug with it. Use a brass rod or hardwood dowel for driving out the plug. The worn bushings may now be driven out and new ones installed. Special pullers are available for removing the steering-knuckle bushings.

Replacing Bronze Bushings in Steering Knuckles (Fig. 346)[1]

In putting new bushings in the steering knuckles, be sure the oil holes in the bushing match with the lubrication fittings, and be very careful to start them in squarely and protect them to pre-

[1] Courtesy of the International Harvester Co.

vent injury. By putting the bushings in the inside of the knuckle, as shown, and removing only one bushing at a time (so as to permit using the steering knuckle pivot placed through the opposite bushing, as illustrated), the possibility of driving the bushing in crooked is eliminated. Here, again, however, care must be taken

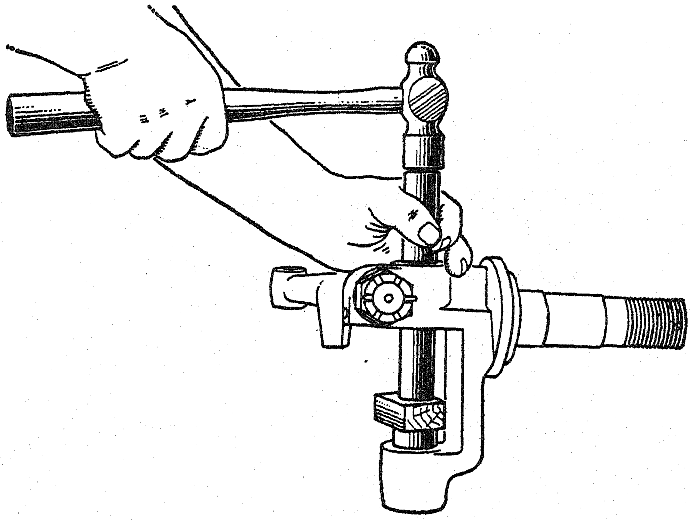


FIG. 346. Installing new steering knuckle or "king pin" bushings.

not to damage the end of the steering knuckle pivot. If available, a lead hammer should be used; if not, and the bushing requires much forcing, the end of the pivot should be protected from the hammer, using hardwood or a copper driving bar.

Replace the steering knuckle pin, retaining bolt and dust plug, and reassemble the wheels and bearings, having them well packed with grease. Adjust the wheel bearings as previously described.

Tie Rod and Drag Link

Examine the bolts or pins at the connections of the tie rod and drag link (Fig. 347). Replace any that are badly worn. Looseness at such connections makes it impossible to align

the wheels properly and causes hard steering. If a ball-jointed connection is used, remove the cotter pin and tighten the screw plug provided for this adjustment.

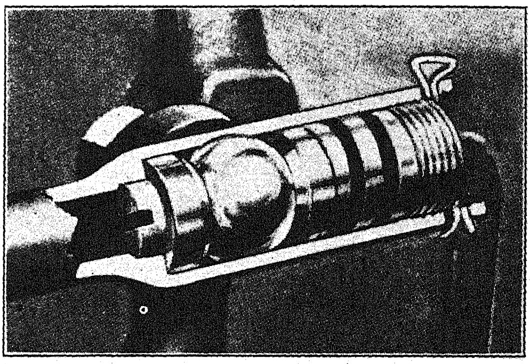


FIG. 347. Ball-and-socket connection between guide arm and drag link.

Front-wheel Alignment

Check the alignment of the front wheels. The tie rod (Fig. 339) should be adjusted so that the front wheels will "toe in" slightly. (See manufacturer's instructions.)

Steering Gear

Take up looseness in the steering gear. Adjustments are usually provided for this purpose. In the construction shown in Fig. 342, adjustment is made by loosening the lock nut and turning the adjustment screw in, thus bringing the worm into closer contact with the worm wheel. Removable bushings are also provided on the worm-gear housing which should be replaced if necessary.

In other types the worm-gear bearing is carried in an eccentric housing. The worm gear may be brought closer to the worm by taking out the cap screws that hold the worm-gear housing and advancing it to a new position, moving it forward one hole at a time, as required to take up the wear. It may also be possible to separate the worm and gear and turn each

one so that new and unworn surfaces will be in contact when reassembled.

Steering-gear Stops

To prevent the front wheels from rubbing against the radius rod, guide rod, frame, etc., steering-gear stops are provided. These prevent the front wheels from rubbing on the radius rods or other parts when short turns are made.

CHAPTER XVIII

OPERATION AND MAINTENANCE

RULES FOR SAFE TRACTOR OPERATION[1]

1. Be sure the gear-shift lever is in neutral before cranking the engine.

2. Always engage the clutch gently, especially when going up a hill or when pulling out of a ditch.

3. When driving on highways or to and from fields, be sure that both wheels are braked simultaneously when making an emergency stop.

4. Always ride on seat or stand on platform of tractor. Never ride on drawbar of tractor or drawn implement.

5. When tractor is hitched to a stump or heavy load, always hitch to drawbar and never take up the slack of chain with a jerk.

6. Be extra careful when working on hillsides. Watch out for holes or ditches into which a wheel may drop and cause tractor to overturn.

7. Aways keep tractor in gear when going down steep hills or grades.

8. Always drive tractor at speeds slow enough to insure safety, especially over rough ground or near ditches.

9. Reduce speed before making a turn or applying brakes. The hazard of overturning the tractor increases four times when speed is doubled.

10. Always stop power take-off before dismounting from tractor.

11. Never dismount from tractor when it is in motion. Wait until it stops.

12. Never permit persons other than the driver to ride on tractor when it is in operation.

13. Never stand between tractor and drawn implement when hitching. Use an iron hook to handle drawbar.

[1] Prepared by the Farm Safety Committee of the Farm Equipment Institute and approved by the National Safety Council, Inc.

14. Do not put on or remove belt from belt pulley while the pulley is in motion.
15. Should motor overheat, be careful when refilling radiator.
16. Never refuel tractor while motor is running or extremely hot.
17. When tractor is attached to a power implement be sure that all power line shielding is in place.

Remember that a *careful operator* always is the *best insurance* against accident.

JOB 32

TO ADJUST THE VALVE-STEM CLEARANCE

Procedure

1. Study Fig. 348 carefully. When the cam points away from the valve tappet, there is an air space between the valve stem

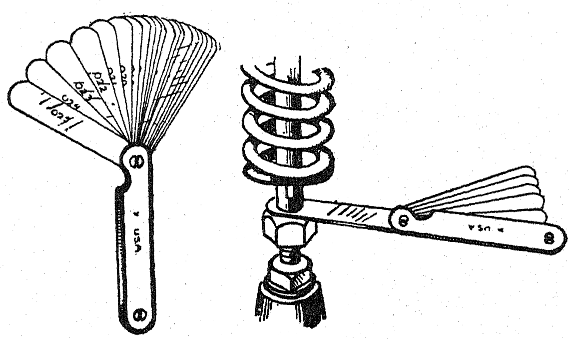


FIG. 348. Measuring valve-stem clearance with thickness gauge.

and the adjusting screw. When the engine runs, these parts get hot and expand. If this air space were not provided, these parts, when hot, would touch all the time and the valve would not close. This space varies on different engines. In some it is 0.010 inch, in others 0.012 inch, etc. The exact spacing should be known. The instruction books provided by the manufacturer give this information. The valve-stem clearance is adjusted between the valve stem and the valve tappet, on L-head en-

gines or between the rocker arm and the valve stem (Fig. 349), on valve-in-head engines.

2. Crank the engine until the valve you wish to adjust is fully closed. Measure the distance between the valve stem and the tappet adjusting screw with a thickness gauge. (This gauge has a number of leaves of different thickness. Select the proper one for the engine you are working on.)

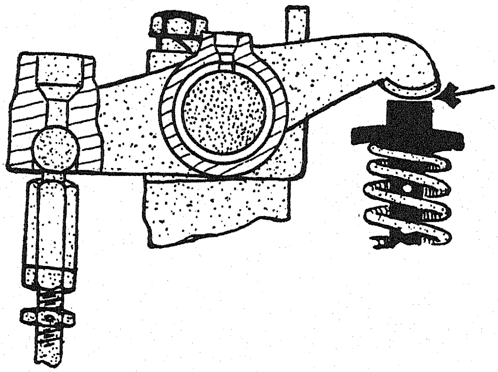


Fig. 349. Adjustment of valve-stem clearance on valve-in-head motor. (Clearance is measured at point indicated by arrow.)

3. Adjust the space so that you can just move the leaf of the gauge between the valve stem and the tappet. This adjustment is made by first loosening the lock nut and then screwing the tappet adjusting screw in or out as necessary.

4. Secure the adjustment when it is right, by tightening down the lock nut. Measure the space with the gauge again, to make sure that it is right. This adjustment is called the *valve-stem clearance*. It must be accurate. If there is not enough space, the valve will open earlier and close later than it should, or it may not seat firmly. If there is too much space, the valve will open later and close earlier than it should. In either case, the cylinder will not develop its full power. In-

sufficient valve-stem clearance usually causes the cylinder to misfire at idling speed or when under light loads.

JOB 33

TO TEST AND ADJUST THE ENGINE BEARINGS

Procedure

1. Drain the oil from the engine and remove the crankcase oil pan.

2. Test each connecting rod. (See Fig. 350.) To do this, crank the engine until any one rod is in the most accessible

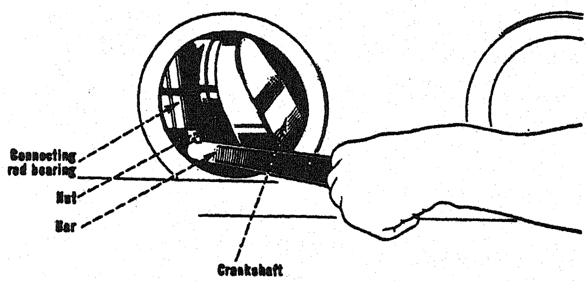


FIG. 350. Testing connecting-rod bearings.

position. Push or pry the connecting rod up and down to see if it is loose on the shaft and can be moved vertically. In some engines the connecting rod is accessible through an inspection plate in the crankcase, in others the oil pan must first be removed.

> NOTE. A certain amount of horizontal movement or side play is permissible, but there should be no noticeable play up and down. Make this test carefully. It is sometimes difficult to discover a slight amount of wear at this point.

3. Remove the cotter pins from the castellated nuts on the bottom of the connecting-rod bolts, and take off the nuts.

4. Remove the bottom half of the connecting-rod bearing. Be careful not to let the shims drop and mix.

5. Remove one shim from each side of the bearing.

6. Put on the bottom cap again and draw the nuts up tight. While testing the fit of one bearing, loosen the nuts on all the other connecting-rod bearings. Test the bearing again for looseness. If it is still loose, remove another shim from each side. Continue removing shims until the connecting rod shows no sign of vertical movement when pushed up and down against the crank shaft. In some cases, shims are not furnished and the bearing is tightened by filing off the lower half or connecting-rod cap (Fig. 351), but it is better to put in new bearing liners.

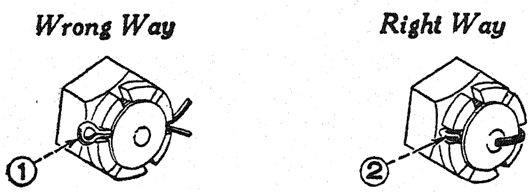


FIG. 351. Method of installing cotter pin in bearing bolts.

Crank the engine. If the bearing has been made too tight, the engine will turn very hard. In this event, it may be necessary to add a thin shim to each side. This bearing must be accurately adjusted. It must be neither too loose nor too tight.

7. Put new cotter pins through the castellated nut. Use the largest size possible, and spread the ends carefully. This cotter pin is essential. If the nuts should come off when the engine is running, a serious smash-up would result. If the castellations on the nut do not line up so that the cotter pin can be inserted, never loosen the nut to get alignment. If necessary, remove the nut on the bottom and file it off slightly. This will permit it to turn a little further, and the cotter pin can be entered with the nut completely tight. (See Fig. 351.)

8. Adjust the other loose, connecting-rod bearings.

9. Replace the crankcase. Be sure that the gasket is in good condition.

10. Tighten all bolts thoroughly. When a connecting-rod bearing is badly worn, it may be necessary to put in new bearing bushings (see Fig. 352).

Adjusting Main Bearings

The main bearings of the crank shaft are adjusted in much the same way as the connecting-rod bearings. They are also fitted with removable shims, which should be removed as the bearing wears. It is usually more difficult to test a main bear-

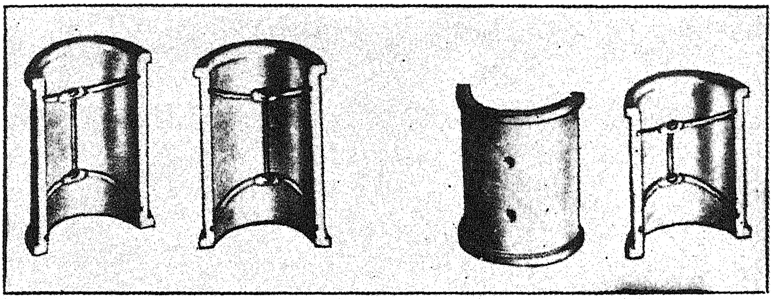


FIG. 352. Bronze-backed babbitt liners for crank-shaft and connecting-rod bearings.

ing because the whole crank shaft must be moved up and down in the bearing in order to detect the wear. To do this, it is advisable to use a bar of iron or a jack so that the shaft may be moved easily. The oil grooves in the bushings of the main bearings and of the connecting-rod bearings should always be cleaned out carefully when the adjustment is made.

Testing Wrist-pin Bearings

The piston is brought to bottom center. One hand is placed so that it rests on both the piston and connecting rod. As the piston is pried upward with a bar, any movement between these two parts is due to wear in the wrist pin or its bushings.

Before this test is made, the connecting rod should be loosened at the crank shaft.

JOB 34

TO RECONDITION THE VALVES AND CLEAN THE CARBON FROM CYLINDERS, CYLINDER HEAD, AND PISTONS

Procedure

1. Drain the water from the radiator.

2. Loosen all connections between the cylinder head and the radiator.

3. Take out all cylinder bolts and remove the cylinder head. Be careful not to break or tear the cylinder-head gasket. Clean the carbon from the inside of the cylinders, cylinder head, and pistons, with carbon scraper, putty knife, or wire brush.

4. Remove the valves. To do this, it is necessary to compress the valve spring and pull out the small pin or washer which retains the valve spring. This is easily done with a valve-spring compressor (Fig. 353).

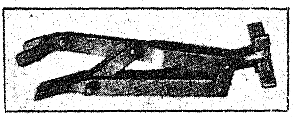


Fig. 353. Valve-spring compressor.

5. Arrange the valves in order. They may then be replaced in the same valve seats. Clean the valve heads, seats, and stems. Polish each valve stem with fine emery cloth. Dirty valve stems are a frequent source of trouble; cleaning them properly is one of the most important steps in caring for the valves.

6. Examine all the valves carefully and replace any that are badly worn or burned or that show indications of being warped or bent.

7. Test each valve in its proper valve guide and clean the valve guide with a narrow strip of fine emery cloth or a guide-cleaning brush such as shown in Fig. 354. Valve guides that are worn so badly that the valve does not seat properly, allowing the valve considerable side play, should be replaced. Test tension of the valve springs and compare them. This may be done by compressing the springs with a valve lifter or similar

tool and noting the tension of each. Any that are noticeably weak should be replaced. Perhaps a more accurate test of the valve-spring tension can be made with all the springs removed. They may then be compressed by hand and weak springs will be readily detected.

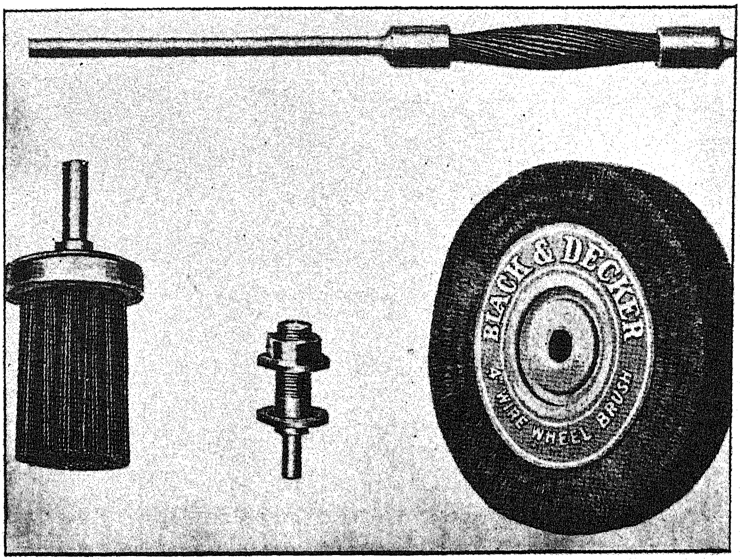


FIG. 354. Valve-guide cleaner and carbon-removing brushes used with electric drill.

8. Grind the valves (hand method).

   (*a*) Place a light spring under the head of the valve as shown in Fig. 355.
   (*b*) Spread a light coating of valve-grinding compound on the seat of the valve. This may be secured at any supply house in small cans, with directions for its use.
   (*c*) Use a screwdriver bit and carpenter's brace or a screwdriver. Press the valve down against the seat lightly and oscillate the tool. Do not turn it com-

pletely around because this motion tends to cut rings or threads on the valve and seat. Raise the valve from the seat frequently and press it down in a new position each time. Add compound as necessary. Wipe off the valve and seat frequently to inspect the work. Grinding should continue until all marks and pits are removed from the valve and seat and an unbroken, grayish, contact surface appears on both parts.

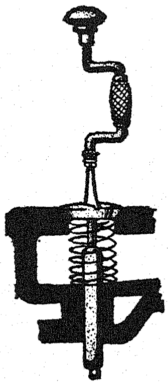


FIG. 355. Grinding valve by hand method.

(*d*) Wash off all traces of the valve-grinding compound and clean all parts. Dip the valve stems in engine cylinder oil and replace all parts.

VALVE RECONDITIONING

Machine- or Service-shop Method[1]

Cleaning Carbon. Scraping carbon by hand is a slow process. It can be removed much faster with the carbon-removing brush in the ¼-inch, heavy-duty drill.

The Black and Decker carbon-removing brush also cleans tops of pistons and valve ports.

Cleaning Valve Guides. Valve guides must be thoroughly cleaned to insure accurate reseating and proper lubrication.

A few strokes with the valve guide cleaner, revolved by the ¼-inch, heavy-duty electric drill, leaves a clean, polished valve guide.

The spiralled wires are expanded to exert a heavy cleaning tension in the valve guide.

Reconditioning the Valve Seats (Fig. 356). The self-centering pilot automatically takes care of the alignment of the seat to its guide.

The reamer, mounted on a sleeve, is revolved about the rigid, accurately centered pilot, cutting a new seat, independent of the old, misaligned one. Narrowing reamers (Fig. 357) are used at

[1] Reproduced by the courtesy of Black and Decker Manufacturing Co.

the top and bottom of the valve seat. A narrow seat contact is desirable.

Cleaning the Valves. Valves are cleaned with a wire wheel brush, revolved by the ¼-inch, heavy-duty drill, which is mounted

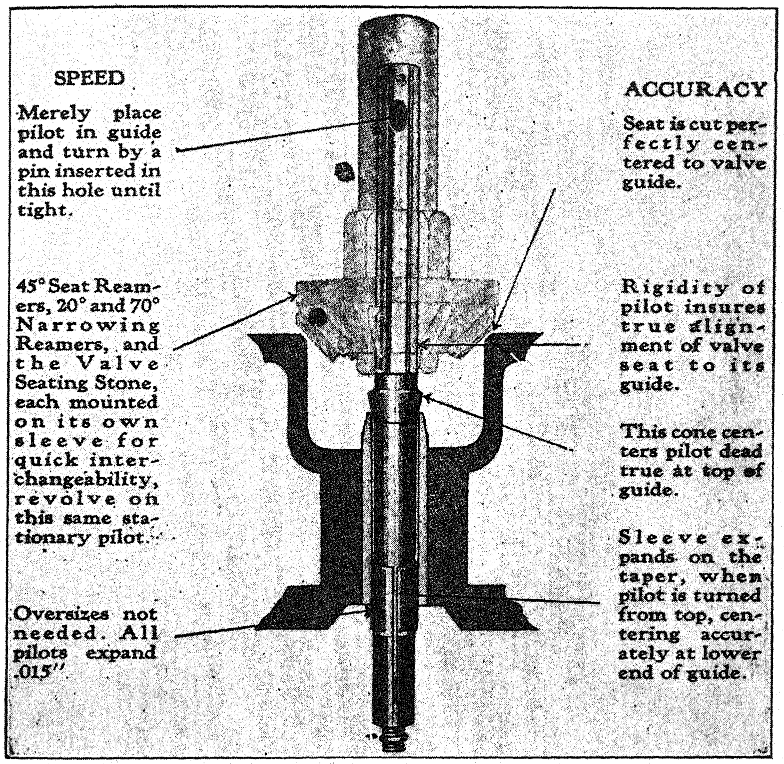


FIG. 356. Reconditioning the valve seat.

in a stand secured to the work bench. This is quicker and more thorough than hand methods, leaving a smooth, burnished surface which does not easily collect carbon.

Refacing the Valve (Fig. 358). The valve also warps, principally above where it runs in the guide, and the alignment between its face and stem is restored by refacing. The Black and

Decker valve refacer, revolving the valve in its precision chuck, grinds a new, highly finished face, concentric to the stem. The

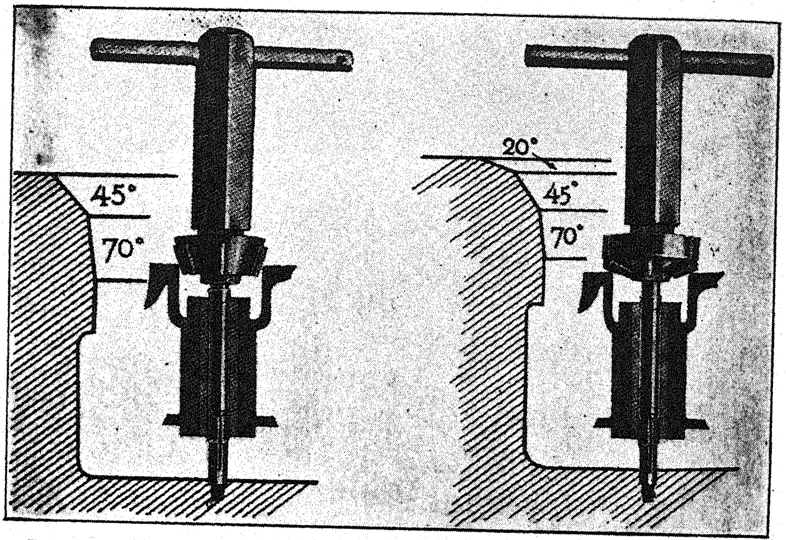


Fig. 357. Narrowing the new valve seat at the top and bottom with 20-degree and 70-degree reamers.

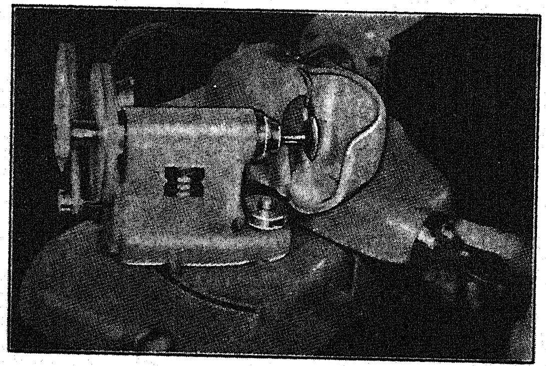


Fig. 358. Refacing a valve by grinding.

grinding wheel of the refacer is quickly trued and sharpened by means of the diamond dressing attachment.

Grinding Valve Seats. Grinding wheels are also furnished for reconditioning the valve seat. (See Fig. 359.) They are accurately centered and leave a smooth, mirrorlike finish. A gauge is supplied for testing the trueness of the valve seat

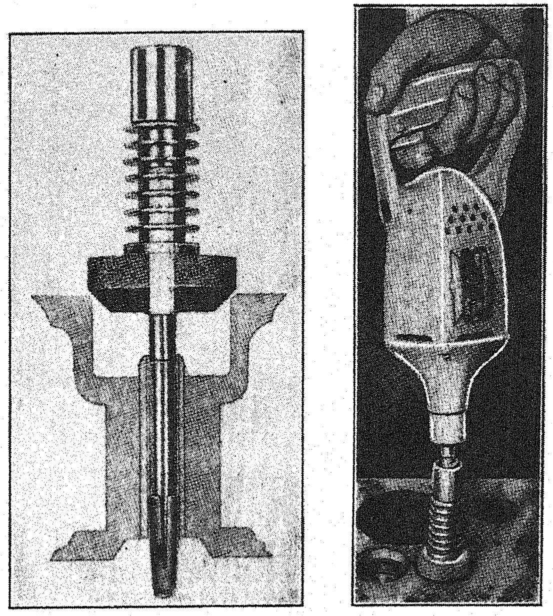


FIG. 359. Grinding a new valve seat.

after grinding. It has a dial indicator which reads in thousandths of an inch.

JOB 35

INSTALLING NEW PISTON RINGS

Procedure

Removing the Pistons

Remove the crankcase oil pan by unscrewing the cap screws attaching it to the bottom of the crankcase. In some designs the pistons may be pulled down past the crank shaft, on the side opposite the camshaft. In others, where the size of the

connecting-rod bearing is less than the diameter of the cylinders, the pistons may be removed by pushing them out the head end of the cylinder. In this case, of course, the cylinder head must also be removed. It is desirable to remove the cylinder head in either design, to facilitate the work of fitting the new rings.

Take off the connecting-rod bearing caps, being careful to keep the shims in place so that they may be replaced on the side of the bearing cap from which they were removed. Also mark each half of the connecting-rod bearing to insure its replacement in the same cylinder and in its original position. When replacing the piston, do not get it turned halfway around in the cylinder. To avoid complications, it is best to complete all the work on one piston before taking out the next one.

Removing Carbon

Remove the old rings from the piston. Scrape the carbon from the piston head, ring grooves, and combustion-chamber surfaces. Narrow strips of emery will be helpful in cleaning out the ring grooves. The carbon may be removed from the other parts with a carbon scraper, putty knife, or old file, if care is used to prevent scratching any of the polished surfaces.

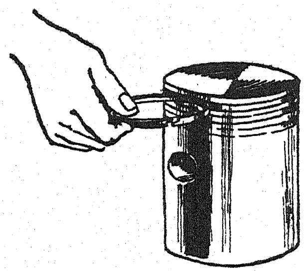


Fig. 360. Testing piston ring in groove.

Fitting Rings to the Piston

Push the new ring into the ring groove and roll it around the piston, as indicated in Fig. 360. If it sticks at any point around the groove, place the ring flat on a sheet of emery paper and press it down. The ring should fit in until it touches the bottom of the groove, and in this position there should not be more than a 0.002- or 0.003-inch clearance between the top edge of the ring.

Fitting Rings to the Cylinder

Place the ring squarely and evenly in the cylinder, as shown in Fig. 361, by pushing it down with the piston from which the rings have been removed. Measure the gap between the ends of the ring with a thickness gauge. The correct ring-gap clearance is usually stated in the manufacturer's instruction

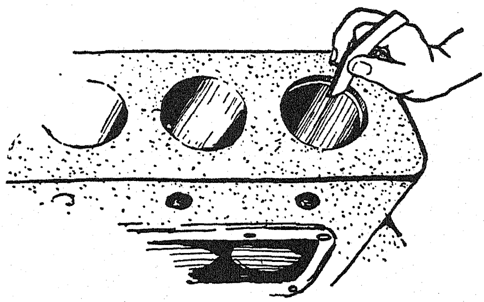


FIG. 361. Measuring ring gap or end clearance.

book. It varies according to the diameter of the piston and cylinder, and thickness of the ring, etc. Rings on the top piston groove are given more clearance than the lower ones. Specifications for top-ring gap clearance vary on different tractors from 0.006 to 0.024 inch, the latter being applicable to pistons of large diameter (5 to 6 inches). The top rings for pistons about 4 inches in diameter are usually given a clearance of 0.010 inch, the next lower ring 0.008 inch, and the lowest ones 0.006 inch. These clearances may be used with satisfactory results for piston diameters in the neighborhood of four inches, if the exact specifications are not available. The lowest ring is usually specially designed to control and restrict lubrication of the cylinder wall.

If the gap clearance is found to be insufficient, remove the ring from the cylinder and file the ends with a small, flat file. Be sure to file them on the same angle that the ring is cut. Repeat the measurement with the ring in the cylinder and continue filing, as required, to obtain the correct clearance. If the gap clearance is too small, the ring, when heated, will

expand; the ends will meet, and the ring should not be used because it may allow the burning gases to "blow by" the piston.

Putting the New Rings on the Piston

In some cases the bottom side of the ring is a trifle larger than the top. If so, it is usually marked, and the rings should be put on with the larger (marked) side down. In this position there is less tendency for the ring to "pump oil." Assemble each ring in its proper groove on the piston. (See ring manufacturer's instructions.)

Replacing the Piston

Before the pistons are replaced the wrist pins should be tested as described in Job 36, and new pins and bushings installed if necessary.

Turn the rings on the piston so that the gaps between the ends of the rings do not fall in a line. Place the gaps about 120 degrees apart.

Rub each piston and cylinder with oil and replace the pistons in the same cylinder from which they were removed.

Adjust and secure the connecting-rod bearings and reassemble all parts.

JOB 36

TO TEST THE WRIST-PIN BEARINGS AND TO FIT NEW WRIST-PIN BUSHINGS

Procedure

1. Refer to Fig. 362. There are two types of wrist pins in general use. The stationary type is fastened to the piston by a setscrew near its outer edge. The removable bushing in this case is between the connecting rod and the wrist pin. The other, the oscillating type (Fig. 363), is clamped securely to the connecting rod by a bolt passing through a groove in its center. For this type, renewable bushings are pressed firmly into the piston.

Test to see if the wrist-pin bushing is worn. Hold the piston firmly with one hand and force the connecting rod back and

forth. If there is wear in the wrist-pin bushings, they must be replaced. These bushings are not adjustable.

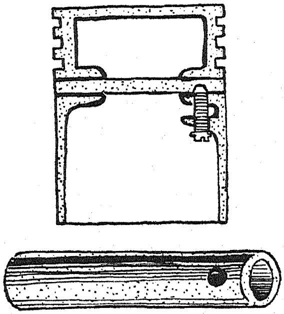


FIG. 362. Stationary wrist pin.

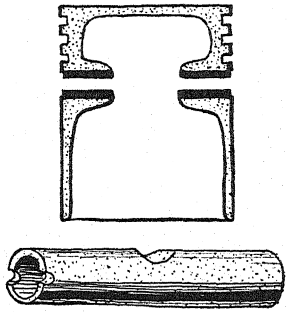


FIG. 363. Oscillating wrist pin.

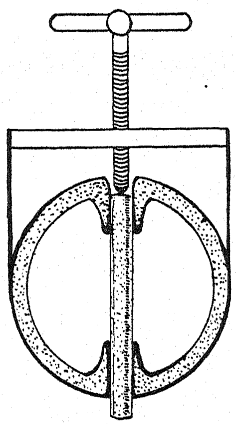


FIG. 364. Tool for removing wrist pin or bushings from piston.

2. Remove the wrist pin and wrist-pin bushings. Figure 364 shows one type of tool used for removing wrist pins or wrist-pin bushings.

(*a*) Loosen the setscrew that holds the wrist pin to the piston of the clamp bolt that holds it to the connecting rod.

(*b*) Press the wrist pin from the piston. If the pin is tight, it is advisable to use the wrist-pin remover.

(*c*) Remove the wrist-pin bushings from the piston or the connecting rod. The bushings may be pressed toward the inside of the piston.

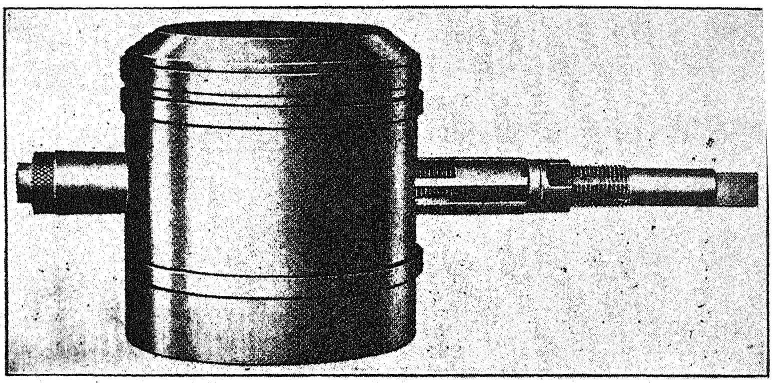


FIG. 365. Adjustable reamer (with pilot) used for enlarging new bushings (Fig. 363) or holes in piston (Fig. 262) so that new wrist pin will enter.

3. Press new bushings into the pistons or into the upper end of the connecting rod. The bushings must enter straight and fit tight. It should require a firm pressure to force them in. They should be pressed into the piston until they clear the outside of it by $\frac{1}{32}$ inch (Fig. 363).

4. Fit the new wrist pins into the bushings. Select a wrist pin that fits the bushing tightly. If the pin is too tight and will not enter the bushing, the bushing must be enlarged slightly. To do this, an adjustable reamer with a pilot or guide is used (Fig. 365). Wipe the bushings and pin clean, after they are properly fitted. Rub oil in the bushings and on the wrist pin. Assemble the parts and tighten the setscrew or clamp bolt.

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